3. Provide, to the extent possible, conservation pools and minimum streamflows in authorizing or developing water storage impoundments and diversion projects.

MA 7A

1. Restore damaged watersheds to satisfactory watershed condition. Watershed treatment is a high priority in this Management Area. Watershed maintenance and improvement may consist of channel stabilization and revegetation using native or non-native species.
2. Manage all programs to eliminate or minimize onsite and downstream water pollution.

New management area 16 contains a standard and guideline under "Watershed and Soil Maintenance and Improvement" that would apply to both groundwater quantity and quality:

1. To the extent practicable, mining facilities and reclamationshould strive to emulate natural hydrologic functions.

Approval of the forest plan amendment would allow actions that would result in impacts to surface water quality. With all of the action alternatives, there is a potential for elevated dissolved silver levels in runoff from waste rock; sediment loads would decrease downstream; and jurisdictional WUS would be directly impacted. Refer to the description of direct, indirect, and cumulative effects presented earlier in this section for further information.

Seeps, Springs, and Riparian Areas

Introduction

One widespread public comment received on the DEIS concerned the organization of the document because the discussion of riparian areas was addressed in multiple resource sections, including the four water resource sections and the "Biological Resources" resource section. For the FEIS, the analysis of impacts to riparian areas has been consolidated into this new section, along with analysis of impacts to seeps and springs, as well as perennial waters.

As used in this document, the word "riparian" is used to describe plant communities associated with natural washes, rivers, ponds, and springs; this definition encompasses a wide spectrum of vegetation types, from wetland areas that might be found along Cienega Creek to the dry washes found on much of the proposed mine site itself. In general, reference in this EIS to "riparian areas" includes not only the riparian vegetation itself (xeroriparian, mesoriparian, or hydroriparian) but any related water sources and the aquatic habitat they represent.

Changes from the Draft Environmental Impact Statement

Three different sources of riparian mapping available for the analysis area were discussed in the DEIS, along with the limitations and characteristics of each mapping source. Public comments questioned the rationale behind the mapping selection used in the DEIS, particularly the perceived dismissal of Pima County mapping efforts. Comments also indicated that, while the Pima County mapping was admittedly more expansive than other mapping sources, the county's mapping efforts focus on habitat corridors, which is a valuable characteristic to consider when addressing riparian areas. The Coronado convened a meeting of cooperating agencies (Garrett 2012e) to discuss riparian mapping needs and reconsider riparian mapping data sources. The Pima County riparian mapping was subsequently selected for use in the FEIS (see the "Riparian Mapping" part of this resource section). This differs from the riparian mapping used in the DEIS.

Several comments, including those from the EPA, stated that the analysis of impacts to both riparian areas and springs was too narrowly focused, assessing only the acres of impacts to riparian areas and the numbers of springs impacted, without fully investigating the physical and biological effects that would be observed. The FEIS supplements the previous measures with an analysis of expected impacts to the function of these springs, seeps, and riparian areas in terms of vegetation type and health (see the "Riparian Condition Assessment" part of this resource section). The approaches used were further refined based on comments from the EPA on preliminary versions of the FEIS.

Regarding seeps and springs, information from additional field investigations conducted since the publication of the DEIS has allowed the seeps and springs inventory to be revised. This has reduced the uncertainty associated with the analysis of expected impacts to seeps and springs (see "Seeps and Springs" under the "Existing Conditions" part of this resource section).

Many commenters, including the EPA and other cooperating agencies, found the analysis of Outstanding Arizona Waters (located in lower Davidson Canyon and along Cienega Creek) to be deficient in the DEIS. A more complete impacts analysis, focusing on criteria specified by regulation as well as the original nomination criteria for those Outstanding Arizona Waters, is included in the FEIS (see the "Outstanding Arizona Waters Analysis" and "Effect on Outstanding Arizona Waters" parts of this resource section).

Some commenters identified areas of intermittent stream channel that were not analyzed, particularly in Sycamore Canyon (north of the mine site), Sycamore Canyon (a different canyon south of the mine site), Box Canyon, and Mulberry Canyon. These areas have been analyzed, but as individual spring locations instead of intermittent reaches (SWCA Environmental Consultants 2013m). The FEIS has been changed to specify that some intermittent channels would be affected along with these springs.

Some comments suggested that the analysis of riparian resources or springs in the Upper Santa Cruz Subbasin, where the mine water supply would be withdrawn, was deficient. The regional water table in this area has historically been high enough to be hydraulically connected to such features but at present is more than 100 feet below the ground surface along the Santa Cruz River and in the vicinity of the pumping wells, and it does not support any riparian or spring resources. Given the amount of groundwater withdrawal from this aquifer for domestic, agricultural, industrial, and commercial uses and given the projections for population growth in the future, it is unlikely that the water table will recover to the point that it would support riparian or spring resources. Therefore, analysis of riparian resources or springs in the Upper Santa Cruz Subbasin remains absent from the FEIS, although it should be noted that some springs analyzed in this section that occur in the Santa Rita Mountains near the mine site are technically within the Upper Santa Cruz Subbasin. Effects on these springs due to mine pit losses are analyzed in full.

Additional mitigation measures have been incorporated into the document and assessed for effectiveness at reducing impacts (see the "Mitigation Effectiveness" part of this resource section, as well as appendix B).

Monitoring has been incorporated into the "Mitigation and Monitoring Plan" (see appendix B) in order to address uncertainty associated with analysis of seeps, springs, perennial waters, and Outstanding Arizona Waters (see the "Mitigation Effectiveness," "Monitoring Intended to Assess Potential Impacts to Stream Flow," "Monitoring Intended to Assess Potential Impacts to Outstanding

Arizona Waters," and "Monitoring Intended to Assess Potential Impacts to Seeps and Springs" parts of this resource section).

Issues, Cause and Effect Relationships of Concern

One significant issue was identified that specifically concerns seeps, springs, and riparian areas (Issue 4). In addition, portions of another significant issue (Issue 3D) pertain to effects on perennial waters and Outstanding Arizona Waters, both of which are addressed in this section.

Issue 3D: Surface Water Availability

Construction and operation of the mine pit, tailings, waste rock, and leach facilities have the potential to change surface water discharge to Davidson Canyon and Cienega Creek, portions of which are designated an Outstanding Arizona Water by the ADEQ. Additionally, the availability of water for stock watering tanks could be reduced.

Issue 3D Factors for Alternative Comparison

1. Number of stream miles changed from intermittent/perennial flow status to ephemeral flow status as a result of the project
2. Quantitative assessment of potential lowering of the water table/reduced groundwater flow to Davidson Canyon and Cienega Creek that results in permanent changes in flow patterns and that may affect their Outstanding Arizona Water[4] designations and current designated uses

Issue 4: Impact on Seeps, Springs, and Riparian Areas

Potential impacts on seeps, springs, and associated riparian vegetation could result from the alteration of surface and subsurface hydrology because of the pit and other operations. Potential impacts could include reduced or eliminated flow to seeps and springs and loss of, or change in, the function of riparian areas.

Issue 4 Factors for Alternative Comparison

1. Acres of riparian areas disturbed, by vegetation classification
2. Number of seeps and springs degraded or lost
3. Change in the function of riparian areas
4. Qualitative assessment of ability to meet legal and regulatory requirements for riparian areas[5]

[4] The State of Arizona has the sole authority to make a determination about whether or not the proposed project would violate State water quality regulations by degrading Outstanding Arizona Waters. The person seeking authorization for a regulated discharge to a tributary to, or upstream of, an Outstanding Arizona Water (in this case Rosemont Copper) has the responsibility to demonstrate to the State of Arizona that the regulated discharge will not degrade existing water quality in the downstream Outstanding Arizona Water. This demonstration by Rosemont Copper, and determination by the State of Arizona, has not yet been completed. Independent of this determination, the potential for degradation of Outstanding Arizona Waters was raised by the public as an issue of importance, and therefore the Forest Service has the responsibility under NEPA to take a "hard look" at the potential for degradation. The analysis in this FEIS uses criteria developed by the Forest Service to assess this potential using available information; however, the State of Arizona would make their own determination using their own regulatory criteria and the information available to them at the time, which could differ from that used by the Forest Service.

[5] This analysis reflects the criteria developed and analyzed by the Forest Service, which will differ from those used by the State of Arizona to make their determination of the ability of the proposed project to meet regulatory requirements.

Analysis Methodology, Assumptions, Uncertain and Unknown Information

Analysis Area

The analysis area includes all areas within which seeps, springs, riparian vegetation, perennial stream flow, or Outstanding Arizona Waters may be impacted (figure 66). The southern boundary of the analysis area runs along the Pima/Santa Cruz County line, which generally represents both the farthest southern extent of modeled groundwater drawdown and the southern extent of available riparian mapping. The eastern and northern boundaries extend far enough to encompass all hydroriparian and mesoriparian areas along Cienega Creek, extending downstream past the Davidson Canyon confluence to the Pantano dam. It should be noted that the biological opinion authored by the USFWS makes reference to Mattie Canyon, which is not within the analysis area for the "Seeps, Springs, and Riparian Areas" resource section of this chapter. Mattie Canyon is located east of Cienega Creek, very near USGS gage no. 09484550, and is generally beyond the area for which the groundwater models estimate impacts (see the "Groundwater Quantity" resource section of this chapter). Potential impacts to Mattie Canyon would be expected to be similar to those for Upper Cienega Creek, as described in this resource section.

The western boundary of the analysis area follows the western extent of modeled groundwater drawdown. As noted in the "Groundwater Quantity" resource section in this chapter, drawdown would be expected to extend beyond the western boundary several hundred years after closure of the mine. No seeps, springs, hydroriparian areas, mesoriparian areas, or perennial flows were identified beyond the boundary that would be affected by the inability to fully analyze drawdown beyond the model boundary (SWCA Environmental Consultants 2013m). The analysis area also incorporates the utility line corridor to the west, as some xeroriparian areas would be impacted by surface disturbance in this area.

The temporal analysis period extends up to 1,000 years in the future, which represents the length of time over which groundwater levels are expected to come into equilibrium.

For analysis of impacts on stream flow and riparian vegetation, the analysis area has been categorized into the following reaches, as shown in figure 67 and summarized in table 106.

Information on these reaches is available from various sources, including site visits in 2012 along Upper and Lower Cienega Creek (WestLand Resources Inc. 2012m), site visits over numerous years along Lower Cienega Creek (Pima Association of Governments 2010b, 2012a; Powell 2013), and site visits in 2010 and 2011 along Davidson Canyon (Tetra Tech 2010a; WestLand Resources Inc. 2011g).

Seeps and Springs

An inventory of springs was compiled from multiple data sources within the analysis area. Data sources included detailed springs inventories conducted for the project in the immediate vicinity of the mine site (Errol L. Montgomery and Associates Inc. 2009b; Tetra Tech 2010a; WestLand Resources Inc. 2007b), springs identified from ADWR water rights data (Pearce 2007), springs identified on USGS 1:24,000-scale topographic maps, and several springs requested to be added by the BLM. However, comments on the DEIS pointed out that uncertainty remained regarding the location and condition of many of these springs. To reduce this uncertainty, in 2011 and 2012 WestLand Resources Inc. conducted field surveys of 104 springs identified within the analysis area, including all springs analyzed in the DEIS (WestLand Resources Inc. 2012j). The results of these field surveys have been incorporated into the springs inventory.

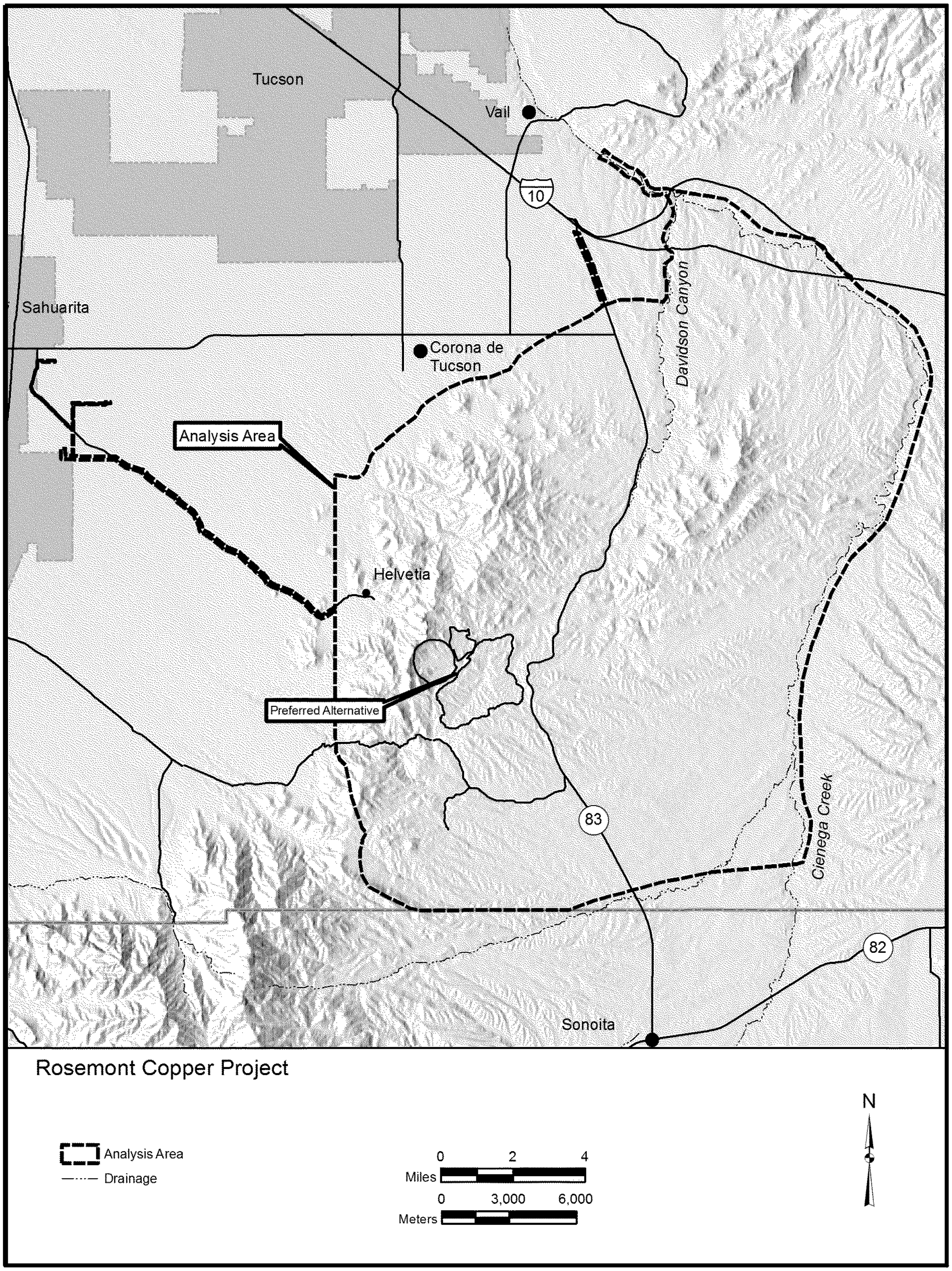

Figure 66. Analysis area for seeps, springs, and riparian areas

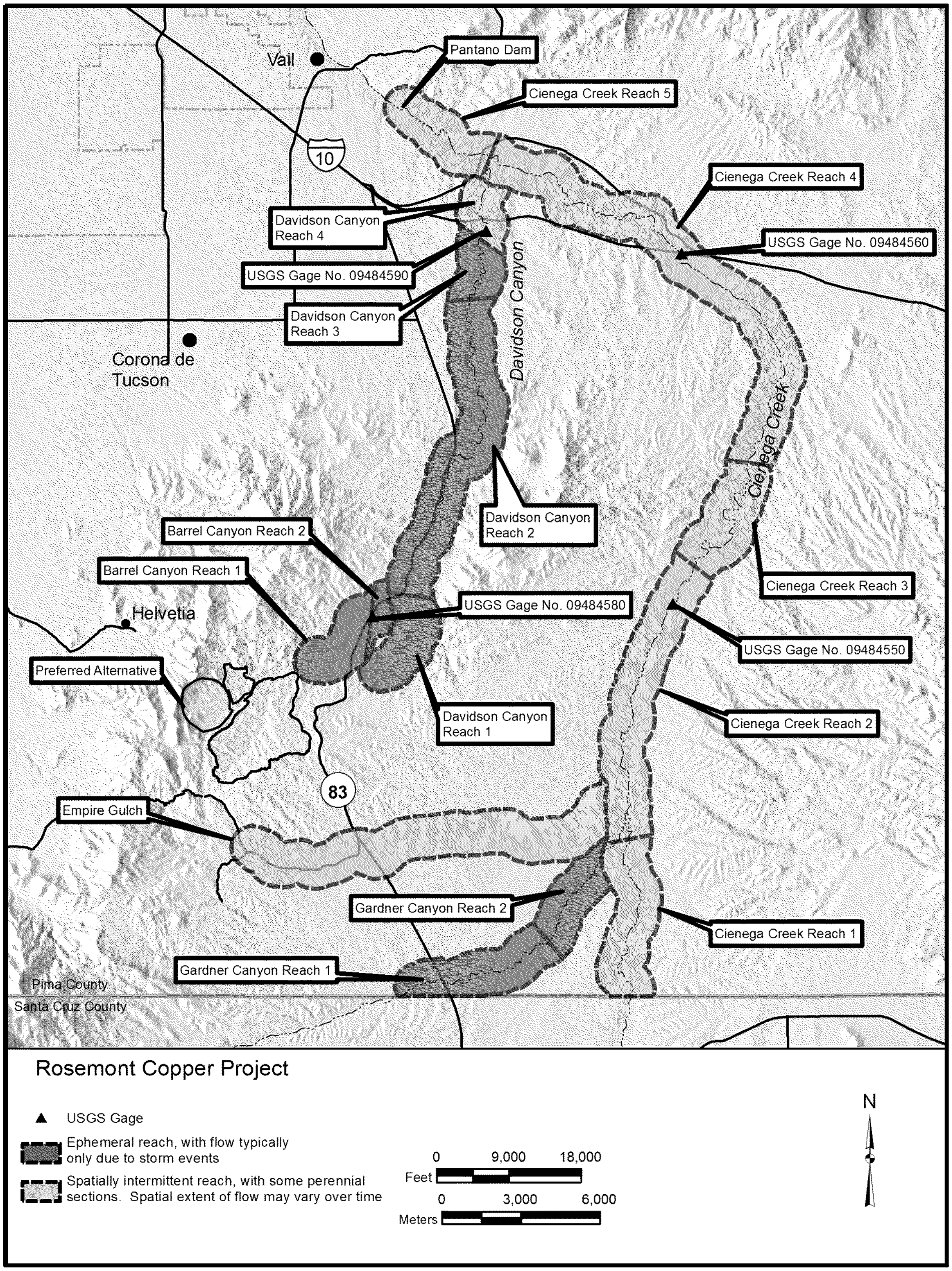

Figure 67. Stream reaches of concern

Table 106. Stream reaches of concern

Reach	General Location	Description of Flow Regime*	Special Status
Cienega Creek 1	From headwaters to confluence with Gardner Canyon	Spatially intermittent; based on comments received from EPA, indications are that some part of the reach above Gardner Canyon exhibits characteristics of perennial flow	None
Cienega Creek 2	From confluence of Gardner Canyon to the Narrows	Spatially intermittent; some perennial reaches; contains USGS gage no. 09484550 (titled "Cienega Creek, near Sonoita"); this gage has been operational since 2001	Outstanding Arizona Water
Cienega Creek 3	The Narrows	Spatially intermittent; some perennial reaches	Outstanding Arizona Water
Cienega Creek 4	From the Narrows to confluence with Davidson Canyon	Spatially intermittent; some perennial reaches; contains USGS gage no. 09484560 (titled "Cienega Creek, near Pantano"); this gage was operational between 1968 and 1975	Outstanding Arizona Water
Cienega Creek 5	From confluence with Davidson Canyon to Pantano Dam	Spatially intermittent; some perennial reaches	Outstanding Arizona Water
Gardner Canyon 1	Upper Gardner Canyon	Ephemeral	None
Gardner Canyon 2	Lower Gardner Canyon	Based on comments received from BLM, approximately 1 mile above the confluence with Cienega Creek, it is perennial	None
Empire Gulch	From headwaters to confluence with Cienega Creek	Spatially intermittent; some perennial reaches; perennial reaches extend approximately 3 miles upstream from confluence with Cienega Creek	None
Davidson Canyon 1	From headwaters to confluence with Barrel Canyon	Ephemeral	None
Davidson Canyon 2	From Barrel Canyon to Davidson Spring	Ephemeral	None
Davidson Canyon 3	From Davidson Spring to Reach 2 Spring	Ephemeral	None
Davidson Canyon 4	From Reach 2 Spring to confluence with Cienega Creek	Has been intermittent or perennial in the past; recently has been intermittent; contains USGS gage no. 09484590 (titled "Davidson Canyon Wash, near Vail'). This gage was operational between 1968 and 1975.	Outstanding Arizona Water
Barrel Canyon 1	From mine site to SR 83	Ephemeral; contains USGS gage no. 09484580 (titled "Barrel Canyon, near Sonoita"). This gage has been operational since 2009.	None
Barrel Canyon 2	From SR 83 to confluence with Davidson Canyon	Ephemeral	None

*** Ephemeral stream:** In a typical year, an ephemeral stream has flowing water only during, and for a short duration after, precipitation events. Ephemeral stream beds are located above the water table year-round. Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow.

Intermittent stream: An intermittent stream has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.

Perennial stream*:* During a typical year, a perennial stream has flowing water year-round. The water table is located above the streambed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow.

Springs occur when groundwater discharges to the ground surface. Flow from seeps and springs in the Rosemont, Davidson Canyon, and Cienega Creek areas can be attributed to the following: (1) discharge of shallow subsurface fracture flow that is directly dependent on storm and runoff events and that may or may not be in direct hydraulic connection with the regional groundwater flow system; (2) discharge of groundwater via fractures that intersect land surface and that are in connection with the regional groundwater flow system; (3) discharge from the recent stream channel alluvium or other shallow aquifer, where it is forced to flow to land surface at bedrock constrictions; and/or (4) discharge of groundwater along low-permeability fault zones that force groundwater to flow to the land surface.

For many of the seeps and springs considered for this analysis, the exact source of groundwater is unknown. The source of water is important to predicting impacts to springs. Springs hydraulically connected to the regional aquifer are likely to be impacted by groundwater drawdown associated with the mine pit. Springs that receive water from local fractures or that are located in ephemeral stream channels may or may not be impacted, even when they are in close proximity to the pit. Many springs may have a mix of regional and local water sources. For springs and seeps, the following qualitative thresholds were established to reflect this uncertainty and are used in this analysis:

- High – The predicted changes in hydrology due to the mine would impact resource function, and the source of water can either be estimated with high certainty to be connected with the regional aquifer, or impacts would occur no matter what the source of water.
- Possible – Reduction in flow could occur, given predicted changes in hydrology as a result of the mine, but uncertainty exists regarding the source of the water. Springs that have not been physically located in the field are assumed to exist, and impacts are considered possible.
- Unlikely – Predicted changes in hydrology as a result of the mine are small enough that they are unlikely to cause a reduction in flow, regardless of the source of water, or the source of the water is local and unlikely to be affected by aquifer drawdown associated with the pit. Springs that fall beyond the modeled 5-foot drawdown contour are considered unlikely to be impacted.

With respect to determining the likely source of water for springs and seeps, several lines of evidence have been considered. These are as follows:

- Multiple and repeated observations of flow or presence of water occurring over several years and different seasons are considered adequate to determine whether a spring is perennial (and therefore likely connected to the regional aquifer) or local. Twenty-three springs have been monitored to this extent; 10 of these were found to be perennial springs likely tied to the regional aquifer.
- One or two repeated observations of flow or presence of water were not considered adequate evidence to determine the likely source of water for a spring. Most springs fall in this category. Most of these visits occurred during summer 2011 or 2012; many springs visited exhibited no flow or presence of water but were only visited during periods with high evapotranspiration, which could reduce spring flow.
- Comparison of spring elevation with the elevation of the regional aquifer was not considered adequate evidence to determine the likely source of water for a spring. This comparison would assume that the water level elevation in the regional aquifer is known with great certainty. Great detail about the water level elevation is known in the immediate vicinity of the mine pit but is necessarily extrapolated elsewhere between fewer data points. Given the

relative complexity of the regional aquifer, this comparison was not considered adequate to determine spring source.

- Isotopic data, where available, were considered adequate evidence to determine the likely source of water for a spring (Tetra Tech 2010a). For the springs in lower Davidson Canyon, isotopic evidence suggests a strong influence of summer precipitation, which would indicate a local source rather than the regional aquifer. Other springs sampled (Deering, MC-1, MC-2, Rosemont, Ruelas, Sycamore) have mixed results that suggest a variety of water sources from both the regional aquifer and more localized sources. Only Questa Spring exhibited a signature that suggests a strong regional source of water.
- Inorganic water quality and temperature can also be used to determine the source of springs. Comparison with other water quality data was not considered adequate evidence to determine the likely source of water for a spring, primarily due to the lack of extensive background sampling with which to make comparisons.

In summary, the FEIS analysis has made use of available data where the data have been deemed sufficient to determine the source of water for individual springs. Only long-term field observations over several years or seasons have provided this level of evidence. For springs without such evidence, springs are assumed to have the potential to be impacted, which is consistent with Forest Service policy.

Riparian Areas

Riparian Mapping

Similar to the DEIS, three sources of riparian mapping are available for the area of analysis: Pima County, the Forest Service, and WestLand Resources Inc. (the latter conducted on behalf of Rosemont Copper). Each source represents different techniques, definitions, and geographic coverage.
The DEIS used a combination of these mapping sources, primarily relying on mapping by WestLand Resources Inc. for the mine site and on Pima County mapping to define hydroriparian and mesoriparian areas elsewhere along major stream corridors.

The Coronado has considered both public comments and input from cooperating agencies and has decided to use the Pima County riparian mapping source in the FEIS. The Forest Service coverage is too limited in geographic extent and largely ignores xeroriparian areas. The Pima County mapping is largely based on remote photographic analysis and generally encompasses a wider swath along washes than that conducted by WestLand Resources Inc., which is based in part on field surveys. However, the underlying purpose of the Pima County riparian mapping is to identify corridors of overall wildlife habitat, whereas the site-specific mapping by WestLand Resources Inc. focused on identifying the extent of specific vegetation species. Determining the presence of wider habitat corridors and their impact to biological resources is one of the primary purposes of analyzing impacts to riparian vegetation in the first place, whether that vegetation lies along dry washes or flowing streams, and this largely informed the Coronado's decision to select the Pima County mapping.
Use of the Pima County mapping offers three benefits: an appropriate focus on habitat corridors, consistency across the area of analysis, and extensive geographic coverage. The Pima County mapping used for the EIS is shown in figure 68.

It is recognized that when compared with onsite surveys such as those conducted by WestLand Resources Inc., discrepancies arise, and the Pima County mapping may in places overestimate the acreage of riparian species impacted WestLand Resources Inc. (2010c) noted that Pima County

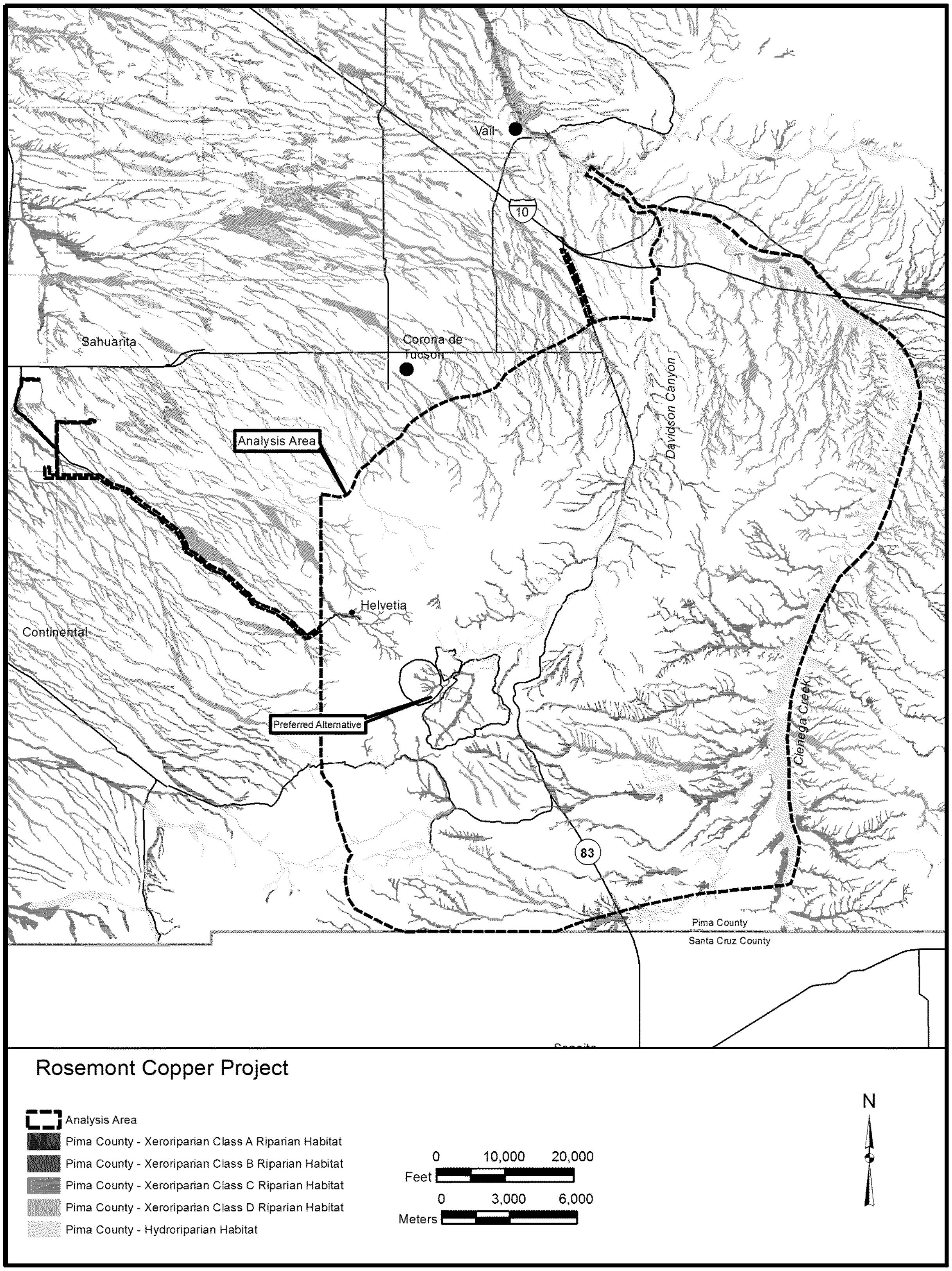

Figure 68. Overview of Pima County mapped riparian habitat

mapping overestimated riparian resources 86 percent of the time in 43 riparian area widths measured in Barrel and Scholefield Canyons. These differences in acreage were determined by the Coronado to be acceptable, given the different criteria used by Pima County. However, in several reaches of Barrel and Davidson Canyons, discrepancies were also evident concerning the overall species types indicated by Pima County mapping and those observed in the field by WestLand Resources Inc. In these cases, acreages have not been changed, but the overall type of habitat has been reinterpreted from that used by Pima County. Each of these instances is discussed in the "Affected Environment" part of this resource section.

Johnson et al. (1984) presented a riparian classification system that focuses on relative abundance and species composition within riparian zones. The riparian mapping of Pima County and of WestLand Resources Inc. is based on this system.

"Hydroriparian" habitats are generally associated with perennial watercourses and/or springs. Plant communities are dominated by obligate or preferential wetland plant species such as willow and cottonwood. The cottonwood/willow forest is a typical example of this habitat type.

"Mesoriparian" habitats are generally associated with perennial or intermittent watercourses or shallow groundwater. Plant communities may be dominated by species that are also found in drier habitats (e.g., mesquite), but they may contain some preferential riparian plant species such as ash or netleaf hackberry. Mesquite bosques and the sycamore-ash association are characteristic of this habitat type.

"Xeroriparian" habitats are generally associated with an ephemeral water supply. These communities typically contain plant species also found in upland habitats; however, these plants are typically larger and/or occur at higher densities than adjacent uplands. Xeroriparian habitat is further divided into four subclasses to reflect the amount of vegetation present.

The Pima County Regional Flood Control District's "Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines" (Pima County Regional Flood Control District 2011) defines the xeroriparian subcategories as follows:

> Xeroriparian A – The most dense xeroriparian subcategory: total vegetative volume greater than 0.856 cubic meters per square meter (m^3/m^2).
>
> Xeroriparian B – Moderately dense xeroriparian subcategory: total vegetative volume less than or equal to 0.856 m^3/m^2 and greater than 0.675 m^3/m^2.
>
> Xeroriparian C – Less dense xeroriparian subcategory: total vegetative volume less than or equal to 0.675 m^3/m^2 and greater than 0.500 m^3/m^2.
>
> Xeroriparian D – Less to sparse plant density xeroriparian subcategory that provides hydrologic connectivity to other riparian habitat areas: total vegetative volume less than or equal to 0.500 m^3/m^2.

USFWS National Wetlands Inventory maps were not relied on for mapping of riparian areas because they do not show all wetlands and do not map riparian areas unless they happen to be mapped wetlands. These maps were derived from aerial photointerpretation with varying limitations due to scale, photo quality, inventory techniques, and other factors. Consequently, the maps tend to show only wetlands that are readily photointerpreted, taking into consideration photo and map scale. Some wetland types were conspicuous and readily mapped, whereas drier wetlands and forested wetlands are more difficult to photointerpret, and larger ones were often missed. Often, the photography was captured during a dry year, making wetland identification equally difficult. The Coronado determined that the Pima County mapping was inclusive of many wetland areas and selected not to use the National Wetlands Inventory maps.

The BLM has also conducted wetland inventories within the Las Cienegas National Conservation Area and has identified more than 30 perennial or seasonal wetlands. Most of these occur on the Cienega Creek flood plain immediately upstream and downstream of the confluence with Empire Gulch, including named wetland complexes such as Cieneguita Wetland, Spring Water Wetland, and Cinco Ponds Wetland. Another complex, the Cold Spring Wetland, occurs upstream of the Mattie Canyon confluence on Cienega Creek. These wetland complexes all occur within the hydroriparian habitat mapped by Pima County along Cienega Creek (see figure 68). Impacts to these wetland complexes are not analyzed individually but are assumed to be part of the analysis of impacts to stream flow and riparian vegetation.

It should be noted that these wetlands may or may not be considered jurisdictional under Section 404 of the CWA. Potentially jurisdictional wetlands under Section 404 must meet specific criteria with regard to hydrology, hydrophytic vegetation, and hydric soils. The analysis undertaken by the Coronado in this resource section is geared toward the physical impacts that may occur to these wetland areas in order to disclose potential impacts as required under NEPA. This is independent of the potential for these wetlands to be jurisdictional under Section 404. The analysis of impacts to WUS considered jurisdictional by the USACE is summarized in the "Surface Water Quality" resource section of this FEIS and is contained in the 404(b)1 Alternatives Analysis in appendix A of this FEIS.

Cooperating agencies identified several areas of intermittent stream that they believed were not reflected in the analysis. In fact, these areas were included but were analyzed as individual spring locations instead of as linear intermittent stream reaches. These include Sycamore Canyon (north of the mine site), Sycamore Canyon (a different canyon south of the mine site), Mulberry Canyon, and Box Canyon. The resources associated with these areas are already fully assessed through the springs and seeps analysis. The analysis indicates which springs correspond to these intermittent streams.

Riparian Condition Assessment

The Coronado met with cooperating agencies (Garrett 2012e) to discuss available techniques, collect additional data from these cooperating agencies, and select an approach for conducting an impact analysis of riparian vegetation.

Numerous techniques were brought to the attention of the Coronado. The ADEQ shared their techniques for Stream Ecosystem Monitoring (Arizona Department of Environmental Quality 2012c). Several agencies identified rapid assessment techniques used throughout the West (Stacey et al. 2006). The Ecological Site Description process used by the Natural Resources Conservation Service was suggested and investigated by the Coronado (Natural Resources Conservation Service 2011). Pima County provided numerous references to local riparian mapping and assessment efforts. Numerous sources in literature were identified that describe the response to or reliance on groundwater levels by various riparian tree species (e.g., cottonwood, willow, tamarisk, mesquite). All of these sources were evaluated by the Coronado for use in the riparian analysis (SWCA Environmental Consultants 2012f). In addition, initial riparian assessments were further refined based on comments from EPA that were received on preliminary versions of the FEIS.

Selected Data Sources

The decision to use the approach to the riparian assessment addressed in this section was informed primarily by an analogous study conducted on the San Pedro River in southeastern Arizona, titled "Hydrologic Requirements of and Consumptive Ground-Water Use by Riparian Vegetation along the San Pedro River, Arizona" (Leenhouts et al. 2006). This study was published by the USGS, with cooperation by numerous other cooperating agencies, including the BLM, ADWR, and EPA. The San Pedro River provides a pertinent analog for the project area, particularly for Cienega Creek and Davidson Canyon. Not only is the San Pedro River geographically close (approximately 20 miles eastward, in the next adjacent valley), but it shares similar elevations (roughly 4,500 to 3,500 feet above mean sea level) and climatology (approximately 12 to 20 inches of rain per year). The San Pedro River also encompasses a wide variety of hydrologic conditions, and, like Cienega Creek, it represents a riparian corridor passing through an alluvial valley with a strong dependence on groundwater resources.

The San Pedro study analyzes the statistical correlation between riparian habitat characteristics and hydrologic and geographic characteristics. Riparian habitat in the San Pedro study differentiated 12 vegetation types. Characteristics of these vegetation types are compared with hydrologic and geographic characteristics such as stream flow persistence, depth to groundwater, groundwater fluctuations, stream flood power, elevation, and flood plain width. The importance of the statistical correlations from the San Pedro study is not necessarily in the exact statistical or numerical relationship, but rather in whether a relationship may exist that is statistically significant, as shown in table 107. For this analysis, these 12 vegetation types have been classified as either hydroriparian/mesoriparian or xeroriparian. In reality, there is a great deal of overlap between these species, and they may occur in a variety of environments with varying degrees of success.

Table 107. Relationships between selected riparian vegetative characteristics and selected hydrologic characteristics based on San Pedro study

Riparian Vegetation Characteristic		Stream Flow Permanence (i.e., perennial vs. intermittent)	Depth to Groundwater	Flood Stream Power (i.e., runoff)
General Category	**Specific Parameter**			
Hydroriparian and Mesoriparian Vegetation Types				
Hydromesic pioneer trees (Fremont cottonwood/Goodding's willow/Arizona sycamore)	Basal area	Perennial flows correlate to greater basal area	None	Greater flood power correlates to greater basal area
	Stem density	Perennial flows correlate to greater stem density for Goodding's willow	Deeper groundwater correlates to less stem density	None
Mesic pioneer trees (tamarisk, tree tobacco, desert willow)	Basal area	Perennial flows correlate to less basal area	None	None
	Stem density	Perennial flows correlate to less stem density	None	None

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Riparian Vegetation Characteristic		Stream Flow Permanence (i.e., perennial vs. intermittent)	Depth to Groundwater	Flood Stream Power (i.e., runoff)
General Category	**Specific Parameter**			
Mesic competitor trees (netleaf hackberry, velvet mesquite, velvet ash, Arizona walnut)	Basal area	Perennial flows correlate to greater basal area	None	None
Hydromesic pioneer shrubs (seepwillow)	Cover	None	None	None
Hydric herbaceous perennials (bulrush, cattail)	Cover	Perennial flows correlate to greater cover	Deeper groundwater correlates to less cover	None
Mesic herbaceous perennials (sacaton grass, other grasses)	Cover	Perennial flows correlate to less cover	Deeper groundwater correlates to less cover	None
Hydric annuals (rabbitsfoot grass, knotweeds)	Cover	Perennial flows correlate to greater cover	Deeper groundwater correlates to less cover	Greater flood power correlates to greater cover
Mesic annuals (sweetclover)	Cover	None, due to mixed results	Deeper groundwater correlates to less cover	Greater flood power correlates to greater cover
Xeroriparian Vegetation Types				
Xeric pioneer shrubs (rabbitbrush, burrobrush)	Cover	None	None	None
Xeric competitor shrubs/small trees (fourwing saltbush, littleleaf sumac, catclaw acacia)	Cover	Perennial flows correlate to less cover	Deeper groundwater correlates to greater cover	None
Xeric annuals (copper leaf, morning glory)	Cover	None	None	None
Xeric perennials (grama, Lehmann's lovegrass)	Cover	None	None	Greater flood power correlates to greater cover

Source: Leenhouts et al. (2006).

Notes:

Relationships shown in this table are only those with statistical significance as reported in Leenhouts et al. (2006).

Competitor: Plants that compete for limited resources such as water or nutrients, resulting in lowered fecundity, growth, or survival of one or more other species.

Hydric: Plants that are intolerant of drought stress and that grow in areas saturated with water.

Mesic: Plants that require intermediate amounts of water and that grow in habitats that are neither excessively wet nor dry.

None: Indicates that no correlation of statistical significance was identified in the San Pedro study.

Pioneer: Plants that are adapted for life in frequently disturbed environments and that occupy areas that were recently disturbed (such as areas cleared by a flood or fire).

Xeric: Plants that grow in dry habitats and that are adapted to survive on limited water.

Additional findings from available literature on the relationship between water availability and flow regimes and plant community response were further researched. The hydrologic/vegetative relationships from those studies are described below (SWCA Environmental Consultants 2012f).

- Researchers at the San Pedro Riparian National Conservation Area concluded that if stream flow became more intermittent and depth to the alluvial groundwater table increased, herbaceous species such as bulrush and rushes would decline in abundance, and streamside-zone species composition would shift toward species such as Bermudagrass. Across the flood plain, cottonwood/willow recruitment rates would decrease and mortality rates would increase; cottonwood/willow forests could give way to tamarisk shrublands (Leenhouts et al. 2006).
- Other researchers found that along the semiarid San Pedro River, hydrophytic species, including cottonwood and willow, dominated at wetter sites, whereas at drier sites, plant communities became dominated by mesophytic species, including saltcedar. Dry sites had increased areal coverage of shrublands and decreased woodland coverage, as well as a decrease in maximum canopy height, total vegetation volume, and upper canopy vegetation volume. Increasing flood disturbance and site water availability led to increased species richness within cottonwood and willow patches (Lite 2004).
- Changes to flood pulses can be expected to result in changes in vegetation composition and structure, wherein alterations to flow may result in a shift in community structure and an eventual loss of biodiversity (Capon 2003).
- Riparian forest communities formerly dominated by Fremont cottonwood and Goodding's willow exhibited vegetative community shifts away from cottonwood/willow following depressed flood plain water tables and changes to duration, intensity, and frequency of flooding (Busch and Smith 1995).
- Maximum canopy height and upper stratum vegetation volume decrease as site water availability declines. Sites with deeper water tables and more intermittent flows had less woodland areal coverage and more shrublands (Lite and Stromberg 2005).
- Semiarid plant communities are adapted to short, regular periods of drought; however, when groundwater levels are artificially lowered, there is a fundamental shift in ecosystem function from one buffered from drought by stable groundwater conditions to one sensitive to small changes in precipitation. Elmore et al. (2003) documented a linear decline in native phreatophytic cover followed by an increase in exotic species in some areas when groundwater was pumped down; in the remaining areas, cover was suppressed.
- Horton and Clark (2001) found that decline of native riparian forests downstream of water diversions is often the result of a lack of successful regeneration of native species. Higher drought tolerance allowed tamarisk seedlings to persist in dry soils where willow seedlings died.
- Most researchers agreed that dense, multiage forests declined in abundance and age-class diversity where water availability was less. Cottonwood/willow forests gave way to tamarisk stands as site-average groundwater depths across the flood plain deepened. Conditions were too dry at intermittent-dry stream flow regime sites to allow for establishment of cottonwood and willow seedlings. Tamarisk abundance increased at dry sites, likely due, in part, to reduced competitive interactions with cottonwood and willow trees(Leenhouts et al. 2006). Similarly, Scott et al. studied sustained cottonwood response to water table decline following in-channel sand mining along an ephemeral sandbed stream. Cottonwood demonstrated a

threshold response to water table declines in medium alluvial sands and sustained 88 percent mortality over a 3-year period (Scott et al. 1999).

Summary of Riparian Vegetation/Hydrologic Relationships

The San Pedro study, as well as other literature cited, was used as a guide for identifying potential cause-and-effect relationships between hydrologic changes and vegetation changes. The following summarizes the relationships used to conduct the analysis of changes to riparian vegetation in the FEIS:

- Hydromesic and mesic trees and shrubs are more common in the presence of perennial stream flow (Fremont cottonwood, Goodding's willow, Arizona sycamore, tamarisk, tree tobacco, desert willow, netleaf hackberry, velvet mesquite, velvet ash, Arizona walnut). Hydromesic trees (Fremont cottonwood, Goodding's willow, Arizona sycamore) also show sensitivity to groundwater declines, including mortality. Declines in groundwater and a resulting transition from perennial to intermittent stream flow would decrease recruitment of cottonwood/willow, increase mortality rates, decrease canopy height and vegetation volume, and encourage transition of cottonwood/willow forest to deeper-rooted tamarisk. Similar to cottonwood and willow, tamarisk (also known as saltcedar) thrives in the presence of abundant groundwater, but it can also extend its roots much deeper than cottonwood or willow as the water table drops.
- With respect to surface flow, increasing flood disturbance encourages species richness within cottonwood and willow patches. Various plant types (hydric annuals, mesic annuals, and xeric perennials) also exhibit greater cover with increased flood disturbance. Declines in surface flow would decrease species richness and cover.
- Hydric and mesic herbaceous perennials (bulrush, cattail, sacaton grass, and other grasses) and hydric and mesic annuals (rabbitsfoot grass, knotweeds, sweetclover) show greater cover in the presence of perennial stream flow and are also sensitive to groundwater declines. Declines in groundwater and a resulting transition from perennial to intermittent stream flow would lead to mortality and declines in abundance of these plants.
- Xeric annuals, perennials, and small shrubs generally show no or slight correlation with perennial flow or sensitivity to groundwater declines.

Comments from cooperating agencies on preliminary versions of the FEIS questioned the lack of analysis of riparian processes, including dissipation of energy, cycling of nutrients, removal of elements and compounds, retention of particulates, export of organic carbon, and maintenance of animal communities. All of these are acknowledged as important functions of riparian areas, and it is acknowledged that these functions would be lost if riparian areas were impacted. However, for the purposes of analysis in the FEIS, impacts to these functions would result from loss of or reduction in health of riparian habitat. Where the FEIS concludes that riparian habitat would be impacted in some manner, there would be a corresponding reduction in the effectiveness of the riparian processes described above, but these riparian processes are not analyzed individually.

Changes in riparian vegetation would also have indirect effects. Reduction in the health of riparian vegetation can increase susceptibility to pests and allow for establishment of invasive species, particularly tamarisk. These in turn can result in increased fuel loads and fire risk, which also increases the risk to nearby healthy riparian areas. Reduction in the health of riparian vegetation can also impact surface flow characteristics like retention and removal of sediment and dissipation of flood flows. The biotic community can be indirectly impacted by changes in nutrient cycling, change in habitat or vegetation cover, and resulting changes in prey base. Changes to the biotic community are addressed in the “Biological Resources” section of this FEIS.

It should also be noted that the assessment of riparian vegetation in this section is meant to provide an analysis of the riparian corridor as a whole. It is understood that certain species or individuals could be more sensitive to hydrologic changes. Specific impacts to special status species are analyzed in more detail in the “Biological Resources” section of this FEIS.

Important Riparian Areas

Important Riparian Areas, as defined by Pima County, are those regulated riparian habitats that have the highest value and can include any of the various classifications of regulated habitat type. They provide critical watershed and water resource management function and landscape linkages and are valued for their higher water availability, vegetationdensity, connectivity factors, and biological productivity, compared with adjacent uplands (Pima County Regional Flood Control District 2010). A total of 494 acres of Important Riparian Areas is located within the project area, including much of Barrel Canyon and its tributaries. An Important Riparian Area is a regulatory distinction but does not factor into the assessment of physical riparian impacts in the FEIS.

Perennial Stream Flow

Effects on perennial stream flow are addressed primarily through groundwater modeling. Quantitative assessments have been used. For the most part, however, the threshold of accuracy for the available models (about 5 feet) renders the analysis of groundwater drawdown on distant surface waters highly uncertain. The conclusion of groundwater experts consulted by the Coronado is that such small drawdowns are beyond the ability of these groundwater models, or any groundwater model, to accurately predict (see the “Groundwater Quantity” resource section in chapter 3). While the analysis of perennial stream flow contained in the “Seeps, Springs, and Riparian Areas” resource section is quantitative, it reflects predicted impacts from relatively small amounts of groundwater drawdown, often fractions of a foot, that are occurring decades, hundreds, or even 1,000 years in the future. It is important to understand that the detailed predictions contained in this section are meant to inform the decision and to show what could potentially happen if the model predictions were to occur as modeled; however, this does not change the overall uncertainty.

Accuracy of the groundwater models is discussed fully in the “Groundwater Quantity” resource section of chapter 3. While there are limitations to the groundwater models, the Coronado reviewed available options and determined that the groundwater models remain the most appropriate tool for estimating potential impacts to surface waters (Ugorets, Cope, and Hoag 2012). The uncertainties involved that lend context to these quantitative estimates are discussed in detail in the “Effect on Perennial Stream flow” part of this resource section.

Based on comments from cooperating and regulatory agencies on several preliminary versions of the FEIS, the methods of assessing impacts to both riparian habitat and perennial stream flow were revised. The revised approach reflects the uncertainty related to the groundwater models by assuming that a range of groundwater drawdown could occur and then assessing the resulting impacts to both perennial stream flow and riparian habitat if those drawdowns were to occur. This does not alleviate the uncertainties involved, but it permits a more quantitative and probabilistic assessment of impacts to stream flow and riparian areas, if drawdowns were to occur as predicted. Each assessment of perennial stream flow and riparian habitat includes these categories: Lowest Estimate; Estimate Based on Best-Fit Models; Highest Estimate. The lowest estimate is based on the smallest drawdown observed in any of the sensitivity analyses from the three groundwater models (see the "Predicted Change in Groundwater Levels as a Result of the Mine Pit" part of the "Groundwater Quantity" resource section). The highest estimate is based on the highest drawdown observed in any of the sensitivity analyses from the three groundwater models.

When conducting modeling sensitivity analyses, ranges of values for different input parameters are modeled in various combinations. Only reasonable values are selected for inclusion in the range of possible values. Thus, any of the sensitivity analyses can be considered to be reasonable outcomes of the modeling. However, while reasonable, the sensitivity analyses are not all equally probable to occur. Model calibration typically results in only one modeling run that is considered to best fit the available real-world hydrologic data (i.e., groundwater levels). These best-fit modeling runs are those that are described and relied upon in the "Groundwater Quantity" resource section of chapter 3. For assessing impacts to stream flow, the "estimate based on best-fit models" represents the best calibrated modeling run from each of the Tetra Tech, Montgomery, and Dr. Myers models.

Actual impacts to stream flow would depend on the specific channel geometry, hydraulic connection with the regional aquifer, and riparian vegetation characteristics. Forest Service policy in the absence of specific data showing otherwise is to assume that water sources are hydraulically connected with groundwater. It has been assumed that Cienega Creek, Empire Gulch, and Gardner Canyon are hydraulically connected with the regional aquifer and that base flow derives solely from this source. In reality, base flow is likely to include both contributions from regional groundwater and storage of storm flows in local shallow alluvial aquifers. The relationship between aquifer water levels and stream flow is not linear, but for the purposes of this analysis it is assumed that a drawdown in the regional aquifer would be reflected by a similar change in the depth of flow in the stream.

Channel geometry and flow characteristics are highly variable along a channel, even within short distances. This is evident from the high longitudinal variability exhibited during annual stream presence/absence monitoring conducted within the Pima County Cienega Creek Natural Preserve, which takes place on Cienega Creek Reaches 4 and 5 (see the "Climate Change" and "Effect on Perennial Stream Flow" parts of this resource section). There is very little detailed channel geometry or flow information anywhere on Upper Cienega Creek, Empire Gulch, or Gardner Canyon, with the exception of one USGS stream gage on Upper Cienega Creek (gage no. 09484550, Cienega Creek near Sonoita). This stream gage has high-quality stream flow, stage, and depth of water measurements for the period of record from 2001 through 2013. This was a period of persistent and severe drought. These stream gage data allow for detailed analysis of how water levels in the stream react to drought and react seasonally at or near the stream gage.

For the purposes of analyzing impacts to Upper Cienega Creek, Empire Gulch, and Gardner Canyon, the predicted modeled drawdowns are superimposed on the actual period of record (2001 through 2013) from the Cienega Creek stream gage. The Cienega Creek stream gage represents only one data point for understanding stream flow changes; however, it was assumed to be representative of Upper Cienega Creek, Empire Gulch, and Gardner Canyon for the purposes of this analysis. While this approach makes use of all available information, the projection may not provide an accurate depiction of likely outcomes of groundwater drawdown on surface flow and habitat at all locations on Upper Cienega Creek, Empire Gulch, and Gardner Canyon.

Once drawdowns are superimposed, two metrics are calculated: the probability or average number of days per year the stream would be dry, and the probability of average number of days per year the stream would experience extremely low-flow conditions (defined as depths of water less than 0.2 foot for the purposes of this analysis). For Upper Cienega Creek, additional corrections are made to account for potential loss of contributing surface flow from Empire Gulch and Gardner Canyon. Drawdown changes of less than 0.1 foot are assumed to result in no impact; this is the smallest increment of drawdown reported from the model sensitivity analyses. Details of the analysis methodology, including detailed calculations of impacts, are contained in the project record (SWCA Environmental Consultants 2013o).

Time Frames for Impacts

As described in the "Groundwater Quantity" resource section, groundwater impacts from pit dewatering were modeled for extremely long periods of time, up to 1,000 years or more, in order to allow the aquifer to come to equilibrium. Uncertainty of modeling results increases with time. For the purposes of analysis of perennial stream flow, seeps and springs, and riparian habitat, it was useful to consider two different time frames: near term and long term.

Near-term impacts are defined as those occurring during the active mine life and up to 50 years after final reclamation and closure. Long-term impacts are defined as those that occur beyond 50 years after final reclamation and closure and up to 1,000 years after final reclamation and closure.

Near-term impacts have a higher level of certainty. Long-term impacts are less certain or even speculative, not only because the uncertainty of the model results increases with time but because the cumulative effects from other future actions and climate change are difficult to predict during these long time frames.

Once groundwater begins to be removed from the aquifer by the mine, either by pumping and dewatering during active mining, or through evaporation from the pit lake after closure, groundwater drawdown in the aquifer proceeds steadily over time, eventually reaching equilibrium when no further drawdown occurs. The various models estimate equilibrium would be reached between 700 and 7,000 years after closure of the mine. For ease of assessing impacts in this section and the "Groundwater Quantity" resource section, several specific points in time were selected for analysis: 50 years after closure, 150 years after closure, and 1,000 years after closure. The analysis does not imply that impacts from groundwater drawdown would occur only at these specific times, but rather that impacts would develop steadily over time before reaching the levels predicted at these specific times.

Outstanding Arizona Waters Analysis

The analysis of potential impacts to Outstanding Arizona Waters focuses on three generalized reaches: Lower Davidson Canyon (Reach 4 in figure 67), Lower Cienega Creek (Reaches 4 and 5 in figure 67), and Upper Cienega Creek (Reaches 1, 2, and 3 in figure 67).

The State of Arizona has the sole authority to make a determination about whether or not the proposed project would violate State water quality regulations by degrading Outstanding Arizona Waters. The person seeking authorization for a regulated discharge to a tributary to, or upstream of, an Outstanding Arizona Water (in this case Rosemont Copper) has the responsibility to demonstrate to the State of Arizona that the regulated discharge will not degrade existing water quality in the downstream Outstanding Arizona Water. This demonstration by Rosemont Copper, and determination by the State of Arizona, has not yet been completed. Independent of this determination, the potential for degradation of Outstanding Arizona Waters was raised by the public as an issue of importance, and therefore the Forest Service has the responsibility under NEPA to take a "hard look" at the potential for degradation. Regulatory requirements associated with Outstanding Arizona Waters relate primarily to antidegradation of water quality, and the State of Arizona will make a determination based on the applicable regulatory criteria, using the information available to them at the time of their assessment. For the analysis contained in this FEIS, the Coronado developed a series of criteria that are different from those that would be used by the State of Arizona. These criteria developed by the Coronado are based not only on regulatory requirements, but also on the reasons that these waters were originally nominated as Outstanding Arizona Waters.

The original nominations for Davidson Canyon and Cienega Creek were reviewed for the characteristics that make these waters unique (Fonseca et al. 1990; Pima Association of Governments Watershed Planning 2005). In general, the following characteristics were identified as justification for nomination: presence of perennial waters; free-flowing condition; good water quality; exceptional recreational or ecological significance, including bird watching, geology, aesthetics, educational use, and use as a wildlife corridor; association with threatened and endangered species, with water quality and quantity being essential to the maintenance and propagation of these species; and for Lower Davidson Canyon, the contribution to stream flow in Lower Cienega Creek through surface or subsurface flow.

For the analysis of Outstanding Arizona Waters undertaken by the Coronado, the potential of the proposed mine to affect the following characteristics has been analyzed using these criteria, which were developed solely by the Coronado and are informed both by regulatory requirements and the nomination criteria:

- Change in the presence of perennial spring or stream flow. For Lower Davidson Canyon and Upper and Lower Cienega Creek, the expected groundwater drawdown associated with the mine pit could have the potential to affect spring or stream flow. For Lower Davidson Canyon and the portion of Lower Cienega Creek downstream of the confluence with Davidson Canyon, the mine site also has the potential to affect stormwater runoff volume.
- Change in groundwater quality. For all three reaches, there is the potential to directly affect groundwater quality.
- Change in surface water quality. For Upper Cienega Creek, changes in stream flow due to groundwater drawdown have the potential to indirectly affect aspects of water quality such as temperature and the ability of the stream to receive contaminants (natural or man-made) without harmful effects on the aquatic system. This ability is known as "assimilative capacity." For Lower Davidson Canyon and the portion of Lower Cienega Creek downstream of the confluence with Davidson Canyon, there is the potential to directly affect surface water quality through stormwater runoff. This includes the ability to meet regulatory standards for antidegradation of existing water quality and regulatory standards for bottom deposits and biological integrity for wadeable, perennial streams. These regulatory standards are discussed later in this section.
- Change in riparian vegetation. For all three reaches, there is the potential to indirectly affect riparian vegetation as a result of changes in either groundwater levels or surface water flow.
- Change in geomorphology. Changes in the surface flow regime could indirectly affect Lower Davidson Canyon and the portion of Lower Cienega Creek downstream of the confluence with Davidson Canyon.
- Change in contributions of subflow from Lower Davidson Canyon into Lower Cienega Creek.

The analysis of potential impacts to Outstanding Arizona Waters necessarily draws on analyses conducted in numerous other resource sections of this EIS. These analyses are summarized but not repeated in their entirety: analyses of groundwater quality and surface water quality are contained in those resource sections, with the exception of potential water quality degradation due to loss of stream flow, which is analyzed elsewhere in this "Seeps, Springs, and Riparian Areas" resource section; analysis of geomorphology is contained in the "Surface Water Quality" resource section; analysis of subflow into Cienega Creek is contained in the "Groundwater Quantity" resource section; and analysis of perennial flows and riparian vegetation is detailed elsewhere in this "Seeps, Springs, and Riparian Areas" resource section.

Scientific Uncertainty and Professional Disagreement

Beginning with the DEIS, and with several preliminary versions of the FEIS, the analysis methodology and conclusions with respect to potential impacts to perennial streams and riparian areas have been reviewed and commented on by cooperating agencies. Significant disagreement about the severity of impacts that could occur to perennial and intermittent streams has arisen, notably from EPA, BLM, and Pima County. In general, this disagreement has centered on two factors: the application of the groundwater models to predict impacts on distant perennial and intermittent streams, and the consideration of exacerbating factors like drought, climate change, and seasonality.

The analysis of potential impacts to stream flow in this section has been refined in an attempt to remove subjectivity and address uncertainty. However, due to the limited accuracy of the groundwater models outside the 5-foot drawdown contour, significant uncertainty remains.
The analysis has two components. First, the impact of predicted drawdown from the mine is compared with existing baseline conditions in the perennial streams of interest; these existing baseline conditions are represented by actual water-level measurements collected on Cienega Creek over a 12-year period (2001 through 2013) and extrapolated from this single site to the rest of Upper Cienega Creek, Empire Gulch, and Gardner Canyon, for the purposes of this analysis only.
The inherent uncertainty in the modeling has been represented by presenting a range of results (low, best fit, high) as previously described.

The second part of the analysis takes into account that there are other exacerbating trends or factors that could increase the severity or probability of impacts. Several of these were identified by EPA (Leidy 2013):

- Ten federally listed endangered and threatened plant and animal species, several of which are obligate aquatic, survive within the Rosemont Copper Project impact and assessment areas. By definition, these species populations are already at risk of local extinction, extirpation, or further population declines under current environmental conditions.
- The long-term trend in surface flows in Lower Cienega Creek is one of continuing decline due to several factors, which may include increasing domestic groundwater pumping and persistent natural drought. One consequence of declining ground and surface water availability is a continuing long-term, decreasing trend in the length of available wetted stream channel along Lower Cienega Creek.
- In response to decreased ground and surface water availability, Pima County has documented changes in the species composition of riparian communities from hydro- and mesoriparian communities to more xeric plant communities. Such changes signal that the system may be

close to an ecological tipping point wherein there will be large-scale, landscape-level changes from wetter toward drier-end riparian communities.

- Climate models predict a trend of increasing temperatures, decreasing precipitation, and increased periods of prolonged drought in the arid American Southwest. This will lead to less available surface and ground water for use by species dependent on these resources.

These exacerbating factors are incorporated in three places in this document. The assessment of impacts under the no action alternative takes into account ongoing trends, including the current drought and observed reductions in surface water availability. The "Climate Change" part of this resource section (and other resource sections) addresses predicted changes in temperature and precipitation. The "Effect on Perennial Stream Flow" part of this resource section consolidates and discusses how these exacerbating factors could change the predictions under existing baseline conditions.

Summary of Effects by Issue Factor by Alternative

Table 108 presents the summary comparison of impacts from each alternative.

Affected Environment

Relevant Laws, Regulations, Policies, and Plans

Relevant laws, regulations, policies, and plans applicable to riparian habitat are discussed in the "Surface Water Quantity" and "Surface Water Quality" resource sections of this chapter.

Outstanding Arizona Waters

Outstanding Arizona Waters are classified by the Director of the ADEQ and are specifically identified by rule (AAC R18-11-112). The primary consideration given to Outstanding Arizona Waters consists of special protections against degradation, known as the Tier 3 Anti-Degradation criteria (AAC R18-11-107D and R18-11-107.01C; 40 CFR 131,12(a)(3)).

Tier 3 Anti-Degradation criteria include several specific requirements:

- New or expanded point-source discharges cannot be made directly to an Outstanding Arizona Water;
- Water quality of a discharge to a tributary of, or upstream of, an Outstanding Arizona Water shall not degrade existing water quality in the Outstanding Arizona Water; and
- A discharge regulated under Section 404 of the CWA that may affect existing water quality of an Outstanding Arizona Water requires a water quality certification from the ADEQ.

In addition, while not specific to Outstanding Arizona Waters, there are also regulatory requirements specific to wadeable, perennial streams (AAC R18-11-108.01 and R-18-11-108.02). Regulations require that a wadeable, perennial stream shall support and maintain a community of organisms having a taxa richness, species composition, tolerance, and functional organization comparable to that of a stream with reference conditions in Arizona. Regulations also have specific requirements for bottom deposits, primarily limiting the percentage of fine sediments, especially in riffle habitats.

Table 108. Summary of effects

Issue Factor	No Action	Proposed Action	Phased Tailings	Barrel	Barrel Trail	Scholefield-McCleary
Issue 3D.2: Number of stream miles changed from intermittent/perennial flow status to ephemeral flow status as a result of the project	None predicted; increased population growth and climate change could have a continued impact on perennial waters similar to trends currently observed	**Empire Gulch, about 3 miles impacted** <u>Low estimate:</u> No or minor changes up to 150 years after closure; ephemeral by 1,000 years after closure <u>Best-fit models:</u> Mixed results showing intermittent or ephemeral by 150 years after closure; all models indicate ephemeral by 1,000 years after closure <u>High estimate:</u> Ephemeral by 50 years after closure **Cienega Creek, about 20 miles impacted** <u>Low estimate:</u> No or minor changes predicted. <u>Best-fit models:</u> Mixed results, with one model showing no or minor changes through 1,000 years, one model showing intermittent conditions by 1,000 years, and one model showing intermittent conditions by 150 years and ephemeral conditions by 1,000 years <u>High estimate:</u> Minor change predicted up to 50 years after closure; intermittent by 150 years after closure; ephemeral by 1,000 years after closure **Davidson Canyon:** No change predicted **Gardner Canyon, about 1 mile impacted** <u>Low estimate:</u> No change predicted <u>Best-fit models:</u> No or minor changes predicted up to 150 years after closure. Mixed results at 1,000 years, ranging from no change to ephemeral. <u>High estimate:</u> Minor changes predicted up to 50 years after closure; intermittent by 150 years after closure; ephemeral by 1,000 years after closure **Intermittent streams:** Some intermittent streams associated with springs in Sycamore Canyon (north), Sycamore Canyon (south), Box Canyon, and Mulberry Canyon may be impacted	Same as for proposed action	Same as for proposed action	Same as for proposed action	Same as for proposed action

Issue Factor	No Action	Proposed Action	Phased Tailings	Barrel	Barrel Trail	Scholefield-McCleary
Issue 3D.3: Quantitative assessment of potential lowering of the water table/reduced groundwater flow to Davidson Canyon and Cienega Creek that results in permanent changes in flow patterns and that may affect their Outstanding Arizona Water* designations and current designated uses	None predicted; increased population growth and climate change could have a continued impact on perennial waters similar to trends currently observed	**Upper Cienega Creek:** Up to 50 years after closure of the mine, most modeling scenarios show no predicted effects At 150 years after closure, some modeling scenarios show no or minor changes in flow, and some modeling scenarios show that there may be transition from perennial to intermittent flow, and increased duration of extremely low-flow conditions At 1,000 years after closure, modeling scenarios are mixed, showing a range of outcomes, including minor changes in flow, transition from perennial to intermittent flow, and transition from perennial to ephemeral flow. All modeling scenarios show increased duration of extremely low-flow conditions. **Davidson Canyon and Lower Cienega Creek:** None predicted; reduction in surface runoff could change recharge to shallow alluvial aquifer; distance downstream makes impacts highly uncertain. Some water quality constituents potentially elevated in runoff, but potential is reduced by waste rock segregation procedures.	Same as for proposed action	Same as for proposed action	Same as for proposed action	Same as for proposed action

Issue Factor	No Action	Proposed Action	Phased Tailings	Barrel	Barrel Trail	Scholefield-McCleary
Issue 4.1: Acres of riparian areas disturbed, by vegetation classification	None predicted; increased population growth and climate change could have a continued impact on perennial waters similar to trends currently observed	Pima County Mapped Riparian Habitat directly disturbed = 686 acres Barrel Canyon = 162 acres of xeroriparian habitat expected to be indirectly impacted with high certainty Empire Gulch = 407 acres of hydroriparian habitat could be indirectly impacted Davidson Canyon (Reach 2) = 502 acres of xeroriparian habitat expected to be indirectly impacted with moderate certainty No riparian habitat is expected to be indirectly impacted along Cienega Creek, Gardner Canyon, or lower Davidson Canyon An additional 14 riparian areas associated with springs would be directly or indirectly disturbed with high certainty; and an additional 35 riparian areas associated with springs may be indirectly disturbed but with less certainty	Pima County Mapped Riparian Habitat directly disturbed = 649 acres Indirect impacts to Barrel Canyon, Empire Gulch, Davidson Canyon, and Cienega Creek are the same as for proposed action Riparian impacts associated with springs are the same as for proposed action	Pima County Mapped Riparian Habitat directly disturbed = 588 acres Indirect impacts to Barrel Canyon, Empire Gulch, Davidson Canyon, and Cienega Creek are the same as for proposed action An additional 13 riparian areas associated with springs would be directly or indirectly disturbed with high certainty; and an additional 36 riparian areas associated with springs may be indirectly disturbed but with lower certainty	Pima County Mapped Riparian Habitat directly disturbed = 633 acres Indirect impacts to Barrel Canyon, Empire Gulch, Davidson Canyon, and Cienega Creek are the same as for proposed action Riparian impacts associated with springs are the same as for Barrel Alternative	Pima County Mapped Riparian Habitat directly disturbed = 631 acres Indirect impacts to Barrel Canyon, Empire Gulch, Davidson Canyon, and Cienega Creek are the same as for proposed action; an additional 19 riparian areas associated with springs would be directly or indirectly disturbed with high certainty; and an additional 32 riparian areas associated with springs may be indirectly disturbed but with lower certainty

Issue Factor	No Action	Proposed Action	Phased Tailings	Barrel	Barrel Trail	Scholefield-McCleary
Issue 4.2: Number of seeps and springs degraded or lost	None predicted; increased population growth and climate change could have a continued impact on perennial waters similar to trends currently observed	Seven springs directly lost due to surface disturbance; 10 springs highly likely to be indirectly impacted due to drawdown; 59 springs may be indirectly impacted due to drawdown, but water source is unknown; 19 springs unlikely to be impacted	Eight springs directly lost due to surface disturbance; nine springs highly likely to be indirectly impacted due to drawdown; 59 springs may be indirectly impacted due to drawdown, but water source is unknown; 19 springs unlikely to be impacted	Five springs directly lost due to surface disturbance; 11 springs highly likely to be indirectly impacted due to drawdown; 60 springs may be indirectly impacted due to drawdown, but water source is unknown; 19 springs unlikely to be impacted	Same as for Barrel Alternative	Thirteen springs directly lost due to surface disturbance; 9 springs highly likely to be indirectly impacted due to drawdown; 56 springs may be indirectly impacted due to drawdown, but water source is unknown; 17 springs unlikely to be impacted
Issue 4.3: Change in the function of riparian areas	None predicted; increased population growth and climate change could have a continued impact on perennial waters similar to trends currently observed	Hydroriparian habitat along Empire Gulch would transition to mesoriparian or xeroriparian Pockets of mesoriparian habitat along Davidson Canyon (Reach 2) could transition to mesoriparian or xeroriparian with moderate certainty Xeroriparian habitat in lower Barrel Canyon highly certain to experience reduced vitality, extensiveness, and health and to transition to lesser quality habitat Along Upper Cienega Creek, widespread transition from hydroriparian to xeroriparian habitat is unlikely, but contraction of hydroriparian habitat could occur with conversion at the transitional margins	Same as for proposed action	Same as for proposed action	Same as for proposed action	Same as for proposed action

Issue Factor	No Action	Proposed Action	Phased Tailings	Barrel	Barrel Trail	Scholefield-McCleary
Issue 4.4: Qualitative assessment of ability to meet legal and regulatory requirements for riparian areas†	Increased population growth and climate change could have a continued impact on perennial waters similar to trends currently observed	**Upper Cienega Creek:** Six criteria assessed for impacts to Outstanding Arizona Waters. Few changes predicted up to 50 years after closure, but some risk in changes of flow and frequency of low-flow conditions in the long-term (see Issue 3D.3). Low-flow conditions could affect biological characteristics under wadeable, perennial standards. **Davidson Canyon and Lower Cienega Creek:** Seven criteria assessed for impacts to Outstanding Arizona Waters. Full analysis of ability to meet water quality requirements Davidson Canyon is not possible, but screening analysis suggests that some constituents may be elevated in stormwater. This potential is reduced by several safety factors, including waste rock segregation requirements. Otherwise, no predicted changes that would affect Outstanding Arizona Waters or biological characteristics protected under wadeable, perennial standards. Geomorphological changes unlikely to affect bottom deposit characteristics protected under wadeable, perennial standards.	Same as for proposed action	Same as for proposed action	Same as for proposed action	Same as for proposed action

* The State of Arizona has the sole authority to make a determination about whether or not the proposed project would violate State water quality regulations by degrading Outstanding Arizona Waters. The person seeking authorization for a regulated discharge to a tributary to, or upstream of, an Outstanding Arizona Water (in this case Rosemont Copper) has the responsibility to demonstrate to the State of Arizona that the regulated discharge will not degrade existing water quality in the downstream Outstanding Arizona Water. This demonstration by Rosemont Copper, and determination by the State of Arizona, has not yet been completed. Independent of this determination, the potential for degradation of Outstanding Arizona Waters was raised by the public as an issue of importance, and therefore the Forest Service has the responsibility under NEPA to take a "hard look" at the potential for degradation. The analysis in this FEIS uses criteria developed by the Forest Service to assess this potential using available information; however, the State of Arizona would make their own determination using their own regulatory criteria and the information available to them at the time, which could differ from that used by the Forest Service.

† This analysis reflects the criteria developed and analyzed by the Forest Service, which will differ from those used by the State of Arizona to make their determination of the ability of the proposed project to meet regulatory requirements.

With respect to the Outstanding Arizona Water in Davidson Canyon, degradation of existing water quality is prohibited. With respect to the Outstanding Arizona Water in Upper and Lower Cienega Creek, both anti-degradation and wadeable, perennial standards would need to be met.

The State of Arizona has the sole authority to make a determination about whether or not the proposed project would violate State water quality regulations by degrading Outstanding Arizona Waters. The person seeking authorization for a regulated discharge to a tributary to, or upstream of, an Outstanding Arizona Water (in this case Rosemont Copper) has the responsibility to demonstrate to the State of Arizona that the regulated discharge will not degrade existing water quality in the downstream Outstanding Arizona Water. This demonstration by Rosemont Copper, and determination by the State of Arizona, has not yet been completed. Independent of this determination, the potential for degradation of Outstanding Arizona Waters was raised by the public as an issue of importance, and therefore the Forest Service has the responsibility under NEPA to take a "hard look" at the potential for degradation. The analysis in this FEIS uses criteria developed by the Forest Service to assess this potential using available information; however, the State of Arizona would make their own determination using their own regulatory criteria and the information available to them at the time, which could differ from that used by the Forest Service.

Existing Conditions

Seeps and Springs

As previously discussed, to reduce uncertainty in the springs inventory, in 2011 and 2012 WestLand Resources Inc. conducted field surveys of 104 springs identified within the analysis area, including all springs analyzed in the DEIS (WestLand Resources Inc. 2012j). Field data collected included survey data, photo documentation, coordinates, elevation, presence of surface water, presence of riparian vegetation, presence of stock watering infrastructure, and description of field efforts. The results of these efforts highlight the uncertainty associated with the springs inventory:

- WestLand Resources Inc. could not survey 22 of the 104 springs because of access constraints; they were either in extremely remote locations or on private property. For the purposes of this analysis, all 22 of these unsurveyed springs remain in the inventory of springs to be considered. They are assumed to exist in functional condition in the location noted.
- The existence of 24 out of the 104 springs could not be verified in the field because the springs could not be located. However, because of field observations (evidence of water staining, tufa deposits, historic stock watering infrastructure, or remnants of more dense vegetation in the vicinity of the presumed spring location), not all of these springs were eliminated from the analysis in the FEIS. It was determined that 16 of these springs are likely intermittent in nature, and these were kept in the springs inventory for analysis. The remaining eight springs were assumed to be transient seeps or to reflect a recording error and were removed from the inventory.
- In all, 95 springs remain in the springs inventory analyzed in this section (figure 69). Detailed seeps and springs observation data obtained during the period 2006 through 2012 are shown in table 109 where available.

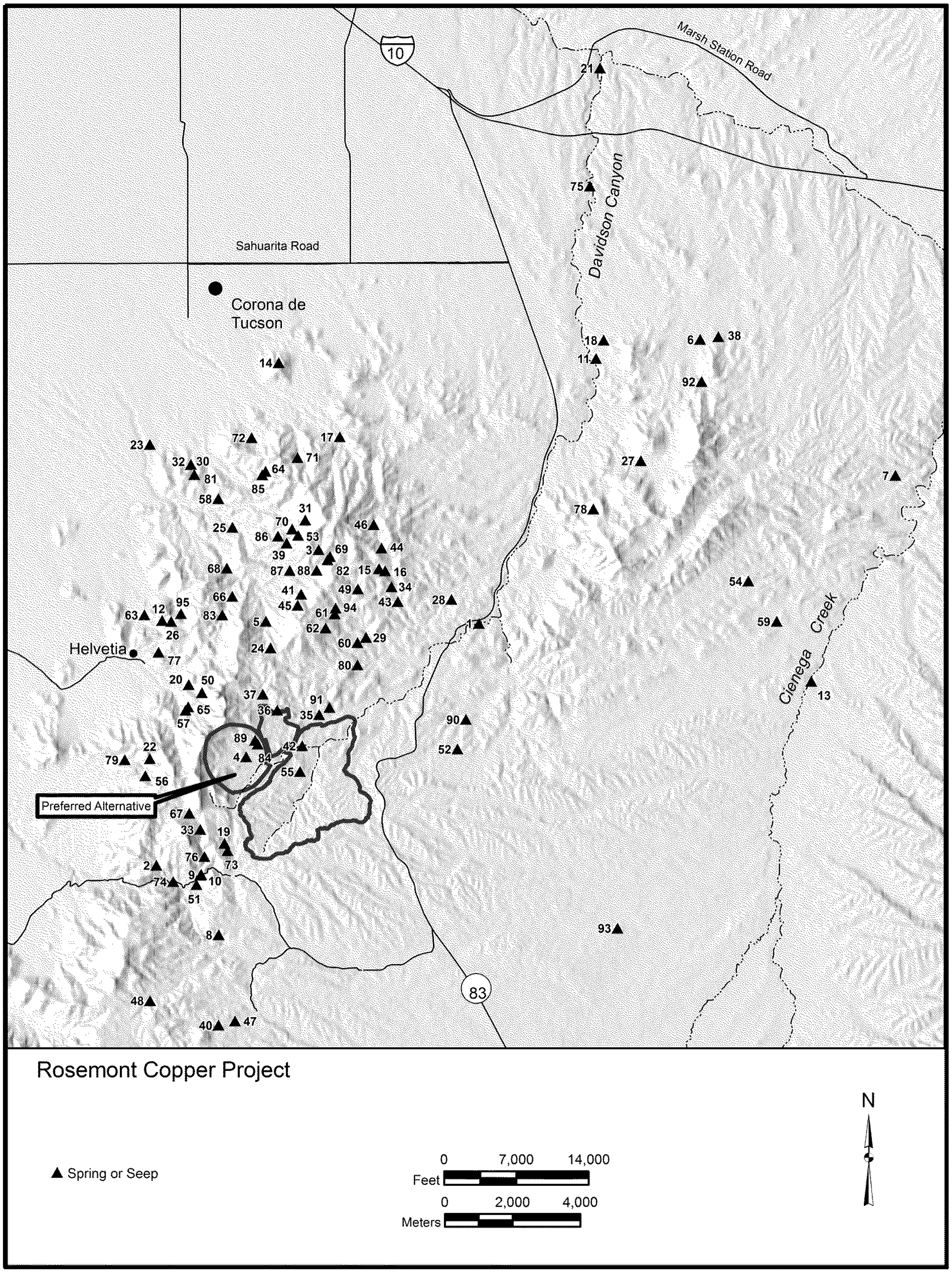

Figure 69. Seeps and springs within the analysis area

Table 109. Seeps, springs, and other water features within the analysis area

ID	Spring (Cadastral Location)	Elevation (feet)	Observed Flow Rate and Characteristics*	Data Source
1	Barrel Spring [D-18-16 14cab]	4,278	Spring observed from 2007 to 2011; long periods with no flow; observed flow up to 1 cubic foot per second	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper Company (2012f); WestLand Resources Inc. (2007b; 2012j)
2	Basin Spring [D-19-15 11bab]	5,018	Evidence of water not observed (summer 2011); riparian vegetation present	USGS (2013c); WestLand Resources Inc. (2011k)
3	Batamout Spring [D-18-16 8ba]	5,044	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k)
4	Bee Spring [D-18-16 31bb]	5,129	Improved. Small seep, <1 gallon per minute (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k)
5	Big Spring [D-18-16 18caa]	4,653	No flow but some evidence of water observed; no riparian vegetation present (summer 2011)	USGS (2013a); WestLand Resources Inc. (2011k)
6	Bobo Spring [D-17-17 21d]	3,980	Unknown; spring not located or observed	USGS (2013a)
7	Bootlegger Spring [D-17-18 31cc]	4,101	Unknown; spring not located or observed	USGS (2013c)
8	Bowman Spring [D-19-15 13ac]	5,156	Improved; no riparian vegetation present (summer 2011)	USGS (2013c); WestLand Resources Inc. (2011k)
9	Box Canyon Spring - Stock Drinker No. 1 [D-19-15 12ba]	4,885	Spring improved, water intermittently present; riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k; 2012j)
10	Box Canyon Spring - Stock Drinker No. 2 [D-19-15 12ba]	4,890	Spring improved, water intermittently present; riparian vegetation present	WestLand Resources Inc. (2012j)
11	California Mine Spring [D-17-17 19db]	3,849	Unknown; spring not located or observed	USGS (2013c); WestLand Resources Inc. (2012j)
12	Chavez Spring [D-18-15 14dbb]	4,407	Water present (summer 2011); riparian vegetation present	WestLand Resources Inc. (2012j)
13	Cold Water Spring [D-18-17 23dbc]	4,240	Unknown; spring not located or observed	ADWR (2005)
14	Cow Spring [D-17-16 19dca]	4,108	Unknown; spring not located or observed	ADWR (2005)
15	Crucero Spring No. 1 [D-18-16 9cbd]	4,800	No water present (summer 2011); riparian vegetation present	WestLand Resources Inc. (2012j)
16	Crucero Spring No. 2 [D-18-16 9cbd]	4,751	Spring observed from 2008 to 2011; long periods without flow; flow observed up to 1.6 gallons per minute; no riparian vegetation present	Rosemont Copper Company (2012f); WestLand Resources Inc. (2012j)
17	Dam Spring [D-17-16 32aac]	4,351	Unknown; spring not located or observed	ADWR (2005)
18	Davidson Spring [D-17-17 19ac]	3,891	Unknown; spring not located or observed	Tetra Tech (2010a)
19	Deering Spring [D-19-15 1dbd]	5,277	Spring observed from 2008 to 2011; consistent flow observed up to 1.59 gallons per minute; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper Company (2012f); WestLand Resources Inc. (2012j)

ID	Spring (Cadastral Location)	Elevation (feet)	Observed Flow Rate and Characteristics*	Data Source
20	Diesler Spring [D-18-15 24cc]	4,830	No water present (summer 2012); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
21	Escondido Spring [D-16-17 30a]	3,341	Spring observed from 2010 to 2011; consistently dry; reports of perennial flow in channel historically	Pima Association of Governments Watershed Planning (2005); Rosemont Copper Company (2012f); Tetra Tech (2010a); WestLand Resources Inc. (2012j)
22	Feliz Spring [D-18-15 35ba]	5,121	Damp, with possible evidence of water (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
23	Fence Spring [D-17-15 35bdb]	3,676	Unknown; spring not located or observed	ADWR (2005)
24	Fig Tree Spring [D-18-16 19abb]	5,068	Spring observed from 2008 to 2011; consistent presence of water with minor dry periods; supports wetland area of approximately 0.5 acre	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper Company (2012f); WestLand Resources Inc. (2010c; 2012j)
25	Heiter Spring [D-18-15 1ddb]	4,151	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k)
26	Helvetia Spring [D-18-15 14dba]	4,570	Spring observed from 2009 to 2011; consistent flow observed up to 3.7 gallons per minute; riparian vegetation present	Rosemont Copper (2012f); WestLand Resources Inc. (2012j)
27	Hilton Spring [D-17-17 32caa]	4,255	Unknown; spring not located or observed	ADWR (2005)
28	Horse Pasture Spring [D-18-16 15aa]	4,333	Evidence of water not observed (summer 2011); riparian vegetation present	Pearce (2007); WestLand Resources Inc. (2011k)
29	HQ Water Spring [D-18-16 16cd]	4,614	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k; 2012j)
30	Indian Spring [D-17-15 36cbc]	3,990	Unknown; spring not located or observed	ADWR (2005)
31	La Cholla Spring [D-18-16 5cba]	5,169	Improved; flow observed (fall 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
32	Little Indian Spring [D-17-15 36cbc]	3,990	Unknown; spring not located or observed	ADWR (2005)
33	Locust Spring [D-19-15 1bdb]	5,468	Spring observed from 2008 to 2011; mostly dry with occasional flowing water; no riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2012j)
34	Lower Mulberry Spring [D-18-16 9dbb]	4,679	Spring observed from 2008 to 2011; consistent presence of water; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f)
35	McCleary Dam [D-18-16 29bda]	4,761	Spring observed from 2008 to 2011; consistent flow observed up to 8 gallons per minute; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2012j)

ID	Spring (Cadastral Location)	Elevation (feet)	Observed Flow Rate and Characteristics*	Data Source
36	McCleary No. 1 [D-18-16 30abc]	4,987	Spring observed from 2006 to 2011; long periods with no flow; flow observed up to 1 gallon per minute; no riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Pearce (2007); Rosemont Copper (2012f); WestLand Resources Inc. (2007b; 2012j)
37	McCleary No. 2 [D-18-16 19cdd]	5,085	Spring observed from 2006 to 2011; consistent presence of water; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2007b; 2012j)
38	Mescal Spring [D-17-17 21a]	4,014	Unknown; spring not located or observed	USGS (2013a)
39	Mesquite Flat Spring [D-18-16 7aaa]	4,709	Presence of water observed (fall 2011); riparian vegetation present	USGS (2013c); WestLand Resources Inc. (2012j)
40	Mine Water Spring [D-19-15 24dc]	5,401	Improved; evidence of water not observed and no riparian vegetation present (summer 2011)	ADWR (2005); WestLand Resources Inc. (2011k)
41	Mudhole Spring [D-18-16 17bb]	4,715	No flow; ground moist; some riparian vegetation present (summer 2011)	ADWR (2005); WestLand Resources Inc. (2011k)
42	Mueller Spring [D-18-16 29cc]	4,838	Improved; evidence of water not observed and no riparian vegetation present (summer 2011)	ADWR (2005); WestLand Resources Inc. (2011k; 2012j)
43	Mulberry Canyon [D-18-16 16a]	4,511	Wetted area in channel; riparian vegetation present (summer 2012)	WestLand Resources Inc. (2012j)
44	Mulberry Spring [D-18-16 9abc]	4,927	Spring observed from 2008 to 2011; consistent presence of water; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f)
45	Oak Spring [D-18-16 17bbc]	4,881	Standing pool; riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k)
46	Ojo Blanco Spring [D-18-16 5cd]	5,012	Improved; riparian vegetation present; presence of water observed (summer 2011)	USGS (2013a); WestLand Resources Inc. (2011k)
47	Ophir Gulch Well [D-19-15 24dd]	5,321	Water about 1 to 1.5 meters below ground level (summer 2012)	WestLand Resources Inc. (2012j)
48	Paja Verde Spring [D-19-15 23ca]	5,546	Evidence of water not observed and no riparian vegetation present (summer 2011)	USGS (2013a)
49	Papago Spring (No. 2) [D-18-16 16bba]	4,800	Spring observed from 2008 to 2011; long periods without flow; flow observed up to 3.57 gallons per minute; no riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2012j)
50	Peligro Adit [D-18-15 24dcc]	5,010	Spring observed from 2008 to 2011; consistent flow observed but has been dry since 2010; no riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2012j)
51	Proctor Box Spring [D-19-15 12bc]	4,841	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k; 2012j)

ID	Spring (Cadastral Location)	Elevation (feet)	Observed Flow Rate and Characteristics*	Data Source
52	Questa Spring [D-18-16 27ddd]	4,604	Small pond present; spring observed from 2007 to 2011; consistent flow observed up to 0.3 gallon per minute; no riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Pearce (2007); Rosemont Copper (2012f); WestLand Resources Inc. (2007b; 2012j)
53	Rock Spring [D-18-16 6ddd]	5,074	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
54	Rockhouse Spring [D-18-17 10cda]	4,490	Unknown; spring not located or observed	ADWR (2005)
55	Rosemont Spring [D-18-16 32bbc]	4,922	Spring observed from 2007 to 2011; consistent flow observed up to 0.79 gallon per minute; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Pearce (2007); Rosemont Copper (2012f); WestLand Resources Inc. (2007b; 2012j)
56	Ruelas Spring [D-18-15 35bdc]	5,029	Spring observed from 2008 to 2011; consistently dry with occasional dampness; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2012j)
57	Ruelas Spring Number Two and Three [D-18-15 26aa]	4,827	No flow, but presence of water observed (summer 2012); no riparian vegetation present	USGS (2013a); WestLand Resources Inc. (2012j)
58	Rust Spring [D-18-15 1acb]	4,212	Unknown; spring not located or observed	ADWR (2005)
59	Sanford Spring [D-18-17 15daa]	4,322	Unknown; spring not located or observed	ADWR (2005)
60	Scholefield No. 1 Spring [D-18-16 16ccc]	4,747	Spring observed from 2007 to 2011; consistently dry; wetland area present (0.3 acre)	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2007b; 2010c; 2012j)
61	Scholefield No. 2 Spring [D-18-16 17adb]	4,883	Spring observed from 2007 to 2011; long periods without flow; flow observed up to 1.3 gallons per minute; no riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2007b)
62	Scholefield No. 3 Spring [D18-16 17caa]	5,117	Most recent observations show flow <1 gallon per minute; ground moist; no riparian vegetation present	WestLand Resources Inc. (2007b; 2011k; 2012j)
63	Shamrod Spring [D-18-15 14bcd]	4,122	Evidence of water not observed (summer 2011); riparian vegetation present	WestLand Resources Inc. (2012j)
64	Siphon Spring [D-17-16 31cda]	4,535	Unknown; spring not located or observed	ADWR (2005); WestLand Resources Inc. (2012j)
65	Soldier Spring [D-18-15 25bb]	4,848	Evidence of water not observed and no riparian vegetation present (summer 2012)	ADWR (2005); WestLand Resources Inc. (2012j)
66	SS-2 (Casita Spring) [D-18-15 13aab]	4,470	Spring observed for 6 months in 2008; no flow or evidence of flow observed; no riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2012j)

ID	Spring (Cadastral Location)	Elevation (feet)	Observed Flow Rate and Characteristics*	Data Source
67	SW [D-19-15 1bbb]	5,540	Spring observed from 2008 to 2011; mostly dry with occasional dampness; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2012j)
68	Sycamore Spring [D-18-15 12dba]	4,211	Spring observed from 2008 to 2011; consistent flow or standing water in sump; flow observed up to 1.3 gallons per minute; riparian vegetation present	Errol L. Montgomery and Associates Inc. (2009b); Rosemont Copper (2012f); WestLand Resources Inc. (2012j)
69	Tree Spring [D-18-16 8acc]	4,915	No water present (summer 2011) but some evidence of past presence of water; some riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
70	Tub Spring [D-18-16 6dd]	4,837	Presence of water observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
71	Tunnel Spring [D-17-16 32cb]	4,436	Unknown; spring not located or observed	USGS (2013c)
72	Tunnel Spring # 2 [D-17-16 31bbd]	4,039	Unknown; spring not located or observed	ADWR (2005)
73	Unnamed Spring (South of Deering Spring) [D-19-15 1d]	5,236	Evidence of water not observed (summer 2012); riparian vegetation present	WestLand Resources Inc. (2012j)
74	Unnamed Spring (in Box Canyon) [D-19-15 11a]	4,772	Pool of water and riparian vegetation observed (2011 and 2012)	WestLand Resources Inc. (2012j)
75	Reach 2 Spring [D-17-17 6bd]	3,518	Spring observed from 2010 to 2011; mostly dry with occasional flow or standing water; reports of perennial flow in channel historically; riparian vegetation present	Pima Association of Governments Watershed Planning (2005); Rosemont Copper (2012f); Tetra Tech (2010a); WestLand Resources Inc. (2012j)
76	Unnamed Spring (in South Sycamore Canyon) [D-19-15 01c]	5,072	Pool of water and riparian vegetation observed (2011 and 2012)	WestLand Resources Inc. (2012j)
77	Unnamed Spring No. 1 [D-18-15 23ba]	4,413	Unknown; spring not located or observed	Pearce (2007)
78	Unnamed Spring No. 12 [D-18-17 6ac]	4,398	Unknown; spring not located or observed	USGS (2013c)
79	Unnamed Spring No. 13 [D-18-15 34aa]	4,830	Presence of water observed (summer 2011); no riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
80	Unnamed Spring No. 14 [D-18-16 21bc]	4,637	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k; 2012j)
81	Unnamed Spring No. 16 [D-17-15 36cc]	4,138	Unknown; spring not located or observed	ADWR (2005)

ID	Spring (Cadastral Location)	Elevation (feet)	Observed Flow Rate and Characteristics*	Data Source
82	Unnamed Spring No. 17 [D-18-16 8ac]	4,993	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
83	Unnamed Spring No. 18 [D-18-15 13ac]	4,657	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
84	Unnamed Spring No. 2 [D-18-16 30cd]	5,152	Standing pool; no riparian vegetation present	Pearce (2007); WestLand Resources Inc. (2011k; 2012j)
85	Unnamed Spring No. 20 D-17-16 31cd]	4,526	Unknown; spring not located or observed	ADWR (2005)
86	Unnamed Spring No. 21 [D-18-16 6dc]	4,805	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2012j)
87	Unnamed Spring No. 22 [D-18-16 7da]	4,552	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k)
88	Unnamed Spring No. 24 [D-18-16 8ca]	4,759	Evidence of water not observed (summer 2011); riparian vegetation present	ADWR (2005); WestLand Resources Inc. (2011k)
89	Unnamed Spring No. 3 [D-18-16 30cd]	5,101	Presence of water observed (spring 2012); no riparian vegetation present	Pearce (2007); WestLand Resources Inc. (2012j)
90	Unnamed Spring No. 4 [D-18-16 26bc]	4,536	Presence of water observed (summer 2011); riparian vegetation present	Pearce (2007); WestLand Resources Inc. (2011k)
91	Unnamed Spring No. 5 [D-18-16 29ab]	4,810	Presence of water observed (spring 2012); riparian vegetation present	Pearce (2007); WestLand Resources Inc. (2011k; 2012j)
92	Unnamed Spring No. 7 [D-17-17 28b]	4,167	Unknown; spring not located or observed	USGS (2013c)
93	Upper Empire Gulch Spring [D-19-17 18aad]	4,610	Presence of water observed (spring 2012); riparian vegetation present	WestLand Resources Inc. (2012j)
94	Water Develop Spring [D-18-16 17ab]	4,846	Improved; standing pool; riparian vegetation present (summer 2011)	ADWR (2005); WestLand Resources Inc. (2011k)
95	Zackendorf Spring [D-18-15 14ada]	4,539	Flow observed in summer 2011, spring 2012, and summer 2012; riparian vegetation present	WestLand Resources Inc. (2012j)

* Flow rate as observed in 2008 and 2009 by WestLand Resources Inc., Montgomery and Associates, or Tetra Tech, or in 2011 and 2012 by WestLand Resources Inc. (2012j).

Little historical information has been consistently collected from these springs with respect to flow quantity, frequency, or water quality; data are limited primarily to observations and sampling in 1975 and again from 2006 through 2012. Little can be said about the long-term seasonal variation in these springs; however, in the discharge measurements collected, all the springs exhibited very low rates of discharge. None of the springs in the vicinity of the project area are particularly large; most have flow of less than 1 gallon per minute. Based on the monitoring period, the following springs appear likely to have perennial flow and therefore are likely tied to the regional aquifer: Rosemont, Helvetia, Sycamore, Questa, Deering, Lower Mulberry, Mulberry, Fig Tree, McCleary Dam, and McCleary No. 2. Isotopic water quality samples are generally mixed, with the exception of those for Questa Spring, which appears to have a signature that strongly suggests a regional water source. However, the isotopic signatures do not rule out contribution from the regional aquifer for any of the other springs listed. Several of the seeps and springs in the analysis area have been developed in the past for stock use, and all of the springs are assumed to be being used for stock and wildlife watering as well as for recreational purposes.

Riparian Areas

Riparian areas mapped by Pima County within the analysis area are summarized in table 110. As noted previously, it was determined that several reaches varied from the Pima County classification. These are explicitly noted in table 110; specific evidence and rationale are discussed below.

Table 110. Riparian affected environment

Reach	Acres of Riparian Habitat	Pima County Riparian Habitat Classification	Species Types Present
Cienega Creek 1	695.13	Hydroriparian	Cottonwood and Goodding's willow*
Cienega Creek 1	364.69	Xeroriparian B	Large mesquites and scrub mesquites with scattered cottonwoods*
Cienega Creek 2	2,086.96	Hydroriparian	Mature cottonwood and Goodding's willow*
Cienega Creek 2	323.98	Xeroriparian B	Mesquite and soapberry†‡
Cienega Creek 2	65.58	Xeroriparian C	Mesquite and soapberry†‡
Cienega Creek 3	382.27	Hydroriparian	Mature cottonwood and Goodding's willow with young velvet ash*
Cienega Creek 3	35.88	Xeroriparian B	Mesquite and netleaf hackberry*
Cienega Creek 3	126.96	Xeroriparian C	Mesquite with desert broom and burrobrush*
Cienega Creek 3	0.78	Xeroriparian D	Mesquite and soapberry†‡
Cienega Creek 4	11.15	Xeroriparian A	Mature mesquite and netleaf hackberry*
Cienega Creek 4	179.52	Xeroriparian B	Mesquites with burrobrush*
Cienega Creek 4	656.81	Xeroriparian C	Less dense mesquites with burrobrush*
Cienega Creek 4	38.58	Xeroriparian D	Mesquite and soapberry†‡
Cienega Creek 4	2138.93	Hydroriparian	Mature cottonwoods and ash with some Goodding's and seep willow*
Cienega Creek 5	4.86	Xeroriparian A	Mesquite*
Cienega Creek 5	21.75	Xeroriparian B	Mesquites with burrobrush*
Cienega Creek 5	168.15	Xeroriparian C	Less dense mesquites with desert broom and burrobrush*
Cienega Creek 5	49.91	Xeroriparian D	Mesquite and soapberry†‡
Cienega Creek 5	463.95	Hydroriparian	Cottonwood and willow gallery forest*
Gardner Canyon 1	356.44	Xeroriparian B	Mesquite and soapberry†‡
Gardner Canyon 1	1.28	Xeroriparian C	Mesquite and soapberry†‡
Gardner Canyon 1	346.55	Hydroriparian	Cottonwood, willow, seepwillow, sycamore, and hackberry†
Gardner Canyon 2	129.29	Xeroriparian B	Mesquite and soapberry†‡
Gardner Canyon 2	121.51	Hydroriparian	Cottonwood, willow, seepwillow, sycamore, and hackberry†
Empire Gulch	86.00	Xeroriparian A	Mesquite and soapberry†‡

Reach	Acres of Riparian Habitat	Pima County Riparian Habitat Classification	Species Types Present
Empire Gulch	631.39	Xeroriparian B	Mesquite and soapberry†‡
Empire Gulch	127.90	Xeroriparian C	Mesquite and soapberry†‡
Empire Gulch	407.46	Hydroriparian	Large cottonwood willow gallery*
Davidson Canyon 1	84.03	Xeroriparian B	Acacia, desert willow, ironwood, paloverde, mesquite, soapberry†
Davidson Canyon 1	99.20	Hydroriparian§	Large ash trees*
Davidson Canyon 2	355.61	Xeroriparian B	Mesquites and hackberry*
Davidson Canyon 2	31.23	Xeroriparian C	Small mesquites and desert willow*
Davidson Canyon 2	33.95	Xeroriparian D	Acacia and desert broom*
Davidson Canyon 2	570.38	Hydroriparian§	Seep willow, Arizona walnut, and cottonwood*
Davidson Canyon 3	0.50	Xeroriparian B	Juniper*
Davidson Canyon 3	28.93	Xeroriparian C	Mesquite and hackberry*
Davidson Canyon 3	26.21	Xeroriparian D	Desert broom and acacia*
Davidson Canyon 3	71.05	Hydroriparian§	Willows, ash, and tamarisk*
Davidson Canyon 4	5.71	Xeroriparian A	Large mesquite and hackberry*
Davidson Canyon 4	5.05	Xeroriparian B	Mesquite*
Davidson Canyon 4	50.42	Xeroriparian C	Small mesquite and juniper*
Davidson Canyon 4	3.27	Xeroriparian D	Desert broom and acacia*
Davidson Canyon 4	174.78	Hydroriparian	Willows, ash, tamarisk, and cottonwood*
Barrel Canyon 1	192.54	Hydroriparian§	Large mesquites, oak, juniper, desert willow, and sumac*
Barrel Canyon 1	21.74	Xeroriparian B	Small mesquites, juniper, and hackberry*
Barrel Canyon 2	12.39	Hydroriparian§	Seep willow*
Total Hydroriparian	**7,940.51**	NA	NA
Total Xeroriparian A	**107.72**	NA	NA
Total Xeroriparian B	**2,575.69**	NA	NA
Total Xeroriparian C	**1,637.06**	NA	NA
Total Xeroriparian D	**152.7**	NA	NA

Note:

NA = Not applicable.

* From actual field observations (WestLand Resources Inc. 2010c, 2012j, 2012m).

† From generic Pima County habitat type descriptions (Pima County Regional Flood Control District 2011).

‡ Vegetation descriptions based on input from BLM.

§ The Pima County habitat designation does not match field descriptions of species types; for purposes of analysis, these areas are considered xeroriparian/mesoriparian instead of hydroriparian.

Riparian Field Descriptions and Variance from Pima County Mapping

The Pima County mapping was supplemented with field descriptions from other sources. Three project-specific riparian studies were reviewed that each cover narrowly defined specific study areas. Below is a list of the project-specific riparian studies and a brief summary of each:

- "Onsite Riparian Habitat Assessment, Rosemont Project," April 2010 (WestLand Resources Inc. 2010c). This onsite riparian habitat assessment was performed based on normalized difference vegetation index display values developed from satellite imagery for the project area, supplemented with field observations. Five different classes of riparian habitat, ranging from xeroriparian to hydroriparian, were delineated.

- "Offsite Riparian Habitat Analysis and Mapping," August 17, 2010 (WestLand Resources Inc. 2011g). The study area for this report consists of upper Barrel Canyon from just north of SR 83 downstream to its confluence with Davidson Canyon and from Davidson Canyon to its confluence with Cienega Creek. This offsite riparian habitat assessment was performed based on normalized difference vegetation index display values from satellite imagery verified by field measurements at 70 locations within the study area.
- "Trip Report for Cienega Creek Site Visit Conducted on October 26–28, 2011, and November 3, 2011" (WestLand Resources Inc. 2012m). The study area for this report consists of Cienega Creek downstream of its intersection with I-10 to the Pantano Dam. Field observations were recorded and photodocumentation provided. Recorded field parameters include vegetation type, dominant species, approximate density, presence of stream flow, and presence of fish.

Much of the Pima County riparian mapping along Cienega Creek matches field descriptions of riparian vegetation species reasonably well. However, field descriptions for several reaches downstream of the proposed mine site in Barrel Canyon and Davidson Canyon do not match well with Pima County mapping. The downstream reaches of Barrel Canyon are identified by Pima County as having 226 acres of riparian habitat, of which 90 percent is mapped as "hydroriparian" (see table 110). Hydroriparian habitat is typified by obligate or preferential wetland plant species, such as willow and cottonwood, and is generally associated with perennial water. Neither cottonwood nor willows were identified in field surveys in Barrel Canyon; seepwillow can also define hydroriparian habitat but was identified at less than 11 percent of sampled points (WestLand Resources Inc. 2010c). In addition, neither perennial nor intermittent water occurs within Barrel Canyon. Barrel Canyon is therefore analyzed in the FEIS as xeroriparian with pockets of mesoriparian habitat and not as hydroriparian habitat.

Of the 1,540 acres of riparian habitat mapped in the Davidson Canyon reaches, 915 acres (60 percent) are classified as hydroriparian by Pima County. Davidson Canyon has been classified in field surveys as largely xeroriparian or mesoriparian, although with individual cottonwood and willows and pockets of higher quality habitat, particularly in the lower reaches (WestLand Resources Inc. 2011g). Only one part of Davidson Canyon has been considered in the past to have perennial flows, which is the lower reach (Davidson Reach 4). For the purposes of the FEIS analysis, Reach 4 of Davidson Canyon is considered hydroriparian; however, Reaches 1 through 3 of Davidson Canyon are analyzed as xeroriparian with pockets of mesoriparian habitat.

Surface Flow

Historical surface water flow data for Barrel Canyon, Davidson Canyon, and Cienega Creek are presented in the "Surface Water Quantity" resource section in this chapter. Surface flow characteristics are summarized by reach in table 106. As noted in the table, some perennial flow has occurred in four of the drainages: in lower Davidson Canyon (Reach 2 Spring to the confluence with Cienega Creek), Cienega Creek (from confluence with Gardner Canyon to Pantano Wash), Empire Gulch, and approximately 1 mile of Gardner Canyon above the confluence with Cienega Creek.

Several intermittent stream channels may exist in the area and these intermittent channels overlap springs that are analyzed and are believed to represent the same physical feature (i.e., a wetted area along an otherwise ephemeral channel). Intermittent reaches may exist in Sycamore Canyon (north of the mine site), Sycamore Canyon (a different canyon south of the mine site), Mulberry Canyon, and

Box Canyon. These intermittent reaches are analyzed in the same manner as the spring locations in these same areas.

Outstanding Arizona Waters

A portion of Davidson Canyon has been designated an Outstanding Arizona Water by the ADEQ after being nominated in 2005 by Pima County. The designated reach begins approximately 12 river miles downstream of its confluence with Barrel Canyon and extends 3.2 miles to its confluence with Cienega Creek. This reach begins approximately where perennial and intermittent stream flow begins, which is associated with discharge from the Reach 2 Spring.

All of Cienega Creek has also been designated an Outstanding Arizona Water by the ADEQ after being nominated in 1990 by Pima County. The designated reach begins at the confluence of Gardner Canyon and extends 28.3 miles to Pantano Dam.

The Outstanding Arizona Water designation ensures that existing surface water quality will be maintained and protected for the designated use of the surface water; existing surface water quality for base flow in Davidson Canyon and Lower Cienega Creek is discussed in the "Surface Water Quality" resource section. The locations of Outstanding Arizona Waters in Davidson Canyon and Cienega Creek are shown in figure 65 in the "Surface Water Quality" resource section.

Environmental Consequences

Direct and Indirect Effects of Each Alternative

No Action Alternative

Under baseline conditions (no action), seeps, springs, and riparian areas within the analysis area would not be impacted by mine activities but would still likely undergo changes from current conditions, uses, and trends. The use of riparian areas for recreation would likely increase relative to the predicted increase in population growth and residential development. Use for stock watering could change, depending on changes in livestock management.

Ephemeral washes in the analysis area will continue to flow in response to precipitation, supporting xeroriparian zones. However, current trends show the impact that prolonged drought can have on spring and stream flow, and these changes could persist or worsen, exacerbated by climate change (see the "Climate Change" part of this resource section). Changes in vegetation type from hydroriparian or mesoriparian to xeroriparian, or from shallow rooted phreatophytic vegetation like cottonwood/willow to deeper rooted vegetation like tamarisk or mesquite could occur as conditions become drier.

Impacts Common to All Action Alternatives

Impacts common to all action alternatives include effects on perennial flows, indirect effects on riparian areas and vegetation, and effects on Outstanding Arizona Waters. The effects on seeps and springs vary between alternatives owing to different footprints of ground disturbance, as do direct effects on riparian vegetation owing to surface disturbance.

The terms "near term" and "long term" are used extensively in the following discussion. As noted earlier, near-term impacts are defined as those occurring during the active mine life and up to 50 years after final reclamation and closure. Long-term impacts are defined as those that occur more than 50 years after final reclamation and closure and up to 1,000 years after final reclamation and closure. Near-term impacts have a higher level of certainty. Long-term impacts are less certain or even speculative, not only because the uncertainty of the model results increases with time but because the cumulative effects from other future actions and climate change are entirely unpredictable during these long time frames.

Effect on Perennial Stream Flow

As shown in table 106, there are several intermittent or perennial stream sections within the analysis area for which impacts from groundwater level changes are a concern:

- Portions of Empire Gulch from Empire Ranch approximately 3 miles to the confluence with Cienega Creek;
- Cienega Creek near the confluence with Gardner Canyon and near stream gage no. 09484550 (Cienega Creek Reaches 2 and 3);
- Portions of Cienega Creek just upstream and downstream of the Davidson Canyon confluence (Cienega Creek Reaches 4 and 5);
- Portions of Gardner Canyon approximately 1 mile upstream of the confluence with Cienega Creek (Gardner Canyon Reach 2); and
- Portions of Davidson Canyon from Reach 2 Spring to the confluence with Cienega Creek (Davidson Canyon Reach 4).

As with springs, changes to perennial flows in streams are highly dependent on the geological conditions that bring about those perennial flows in the first place. Perennial flow can result from discharge of water from the regional aquifer into the streambed as a result of the intersection of fracture zones or upwelling from regional groundwater flow encountering a flow barrier. Perennial flow can also result from discharge of shallow groundwater that is stored and moving subsurface in alluvial stream sediments, and that is forced to the surface by geological conditions, such as bedrock constrictions of the stream channel. In the case of this shallow alluvial groundwater, changes in ephemeral surface flows are more likely to impact perennial flows than changes in regional groundwater levels.

Uncertainty, Trends, and Exacerbating Factors

Analysis of potential impacts to perennial streams from drawdown of groundwater in the regional aquifer has been refined since the DEIS by the Coronado in response to comments by the public, cooperating agencies, and EPA. The analysis contained in this section makes use of the best available science, data, and tools to quantify the increased risk of negative outcomes in Empire Gulch, Cienega Creek, and Gardner Canyon to the extent possible. Negative outcomes include both risk of drying as well as risk of extremely low-flow conditions occurring, which can negatively affect water and habitat quality and the organisms that depend on these resources. The intent of this analysis is to disclose the full range of possible effects on perennial stream flow, using quantification and probability based on the best available science, data, and tools while also informing these results with qualitative discussion of trends and exacerbating factors occurring in the watershed.

While the analysis contained in this section is quantitative, it reflectspredicted impacts from relatively small amounts of groundwater drawdown, often fractions of a foot, that are occurring decades, hundreds, or even a thousand years in the future. The conclusion of groundwater experts consulted by the Coronado is that such small drawdowns are beyond the ability of these groundwater models, or any groundwater model, to accurately predict (see the "Groundwater Quantity" resource section in chapter 3). It is important to understand that the detailed predictions contained in this section are meant to inform the decision and to show what could potentially happen if the model predictions were to occur as modeled; however, this does not change the overall uncertainty.

There are other trends and exacerbating factors occurring in the watershed that add to the uncertainty of predicting impacts to perennial streams. These are discussed elsewhere in the document (see the "No Action" and "Climate Change" parts of this resource section), but it is important to reiterate them here as well to help inform the impact predictions contained in this section. These factors include climate change, current stress and downward trends observed on Lower Cienega Creek, and increases in groundwater pumpage within the Cienega Creek basin. While these factors add to the overall uncertainty, they provide general trends that can also inform the decision.

Climate Change and Recent Trends

Climate change in the desert Southwest is predicted to bring about higher mean annual temperatures over the next 100 years, along with less winter precipitation, an increase in extreme rainstorms and flooding, and longer periods of drought. The impact these changing climate conditions would have on perennial streams like Cienega Creek is not simple to predict. A great deal willdepend on how and where rainfall occurs (i.e., summer monsoons versus winter frontal storms) and on the ultimate source of water for perennial streams. Several good summaries of the variability of expected climate change are available (Overpeck et al. 2012). Models consistently suggest rising temperatures, but effects on precipitation, and especially seasonal timing of precipitation, are less consistent. Climate models differ in the amount of reduction expected to be experienced during summer and winter storm events (Overpeck et al. 2012). The reaction of riparian vegetation to changing climate conditions will also have its own influence on water availability in riparian areas. These changes are difficult to predict on a site-specific basis. For instance, as noted elsewhere in this section, spring water samples analyzed for isotopes suggest that some springs (in lower Davidson Canyon) are strongly influenced by summer precipitation, whereas others are more influenced by winter precipitation. However, while site-specific predictions are difficult, there is general agreement that temperatures will rise and overall water availability is likely to decrease due to climate trends.

Local drought and recent fluctuations in climate should not automatically be considered indicative of long-term climate change; there have always been drought cycles in the desert Southwest, interspersed with abnormally wet conditions. Climate change would not interrupt this cycle but is predicted to exacerbate drought and cause overall changes in the length and frequency of drought periods. The Cienega Creek basin, like the rest of Arizona, is currently in the midst of a multi-decadal drought that began, by most counts, in the late 1990s and, with the exception of a few wet years, has yet to be alleviated. While the ongoing drought may or may not be the result of long-term climate change, the trends observed because of the drought are useful as examples of the long-term effects that would result from climate change.

Pima County has recently documented many of the long-term changes observed on the Cienega Creek Natural Preserve between 1990 and 2011 (Powell 2013), located along what is usually referred to as Lower Cienega Creek (Cienega Creek Reaches 4 and 5, as shown in figure 67). Measurements of drought severity indicate that drought conditions have roughly been ongoing in the Cienega Creek basin since 1996. Over this period, Lower Cienega Creek has seen noticeable reductions in both the amount of stream flow, the geographic length of stream flow, and the average depth to groundwater. Causes for these changes are likely varied, but persistent drought is one of the leading stressors.

Two other trends concerning Cienega Creek are also pertinent. When reviewing these, it is important to understand the distinction between Lower Cienega Creek and Upper Cienega Creek. Upper Cienega Creek is generally considered to extend from the headwaters downstream to an area known as the “Narrows,” which is located about 7 to 8 miles upstream of I-10 (Cienega Creek Reaches 1, 2, and 3, as shown in figure 67). Upper Cienega Creek generally flows through basin fill alluvium, with some limited pockets of younger alluvium. The basin fill alluvium is generally assumed to be part of the regional aquifer, which would be impacted by drawdown from the mine or other aquifer dewatering. Upper Cienega Creek flows through the Las Cienegas National Conservation Area and includes the tributaries of Gardner Canyon, Mattie Canyon, and Empire Gulch.

Lower Cienega Creek, located below the Narrows, generally is characterized by flow through younger alluvium. There are likely still hydraulic connections between the younger alluvium and the regional aquifer, but ephemeral storm flows are also important to replenish the shallow alluvium along Lower Cienega Creek. Lower Cienega Creek largely flows through Pima County’s Cienega Creek Natural Preserve, eventually terminating at Pantano Dam, several miles below the confluence with Davidson Canyon.

The hydrologic monitoring in Cienega Creek Natural Preserve and the documentation of downward trends in stream flow are pertinent to Lower Cienega Creek. Two similar sources of data farther upstream on Upper Cienega Creek include a stream gage operated by the USGS (no. 09484550; Cienega Creek near Sonoita) and reported monitoring of wetted stream length within the Las Cienegas National Conservation Area. Neither source shows a similar downward trend. Stream flow and water levels are available from the USGS stream gage from 2001 through 2013; these data are key to the analysis of potential impacts from the mine discussed later in this section (see figure 70). While Upper Cienega Creek experienced one very dry month in May/June 2010 when flow ceased, overall there has not been a major downward trend in winter or summer base flow similar to that observed in Lower Cienega Creek during the same period (Powell 2013:figure 12).

In addition, it has been reported by Pima County that stream flow conditions have been monitored within BLM Las Cienegas National Conservation Area like they have been monitored within the Pima County Cienega Creek Natural Preserve. These data have not been made available for analysis by the Coronado. The results are interpreted and reported by Pima County (Powell 2013). According to Pima County interpretation of these data, flow extent on Upper Cienega Creek decreased between 1990 and 2012 but also actually increased during the period 2006 through 2011, opposite the trend on Lower Cienega Creek (Powell 2013:figure 32).

These differences in response to drought conditions likely reflect differences in hydrologic connection with the regional aquifer and sources of groundwater supporting perennial stream flow.

Groundwater Use and Pumpage in Cienega Basin

As discussed in the “Groundwater Quantity” resource section, wells in the project area are primarily used for domestic and stock water uses and have sustainable well yields from less than 1 to 3 gallons per minute. Estimates of groundwater use by wells within the Davidson Canyon/Cienega Basin are approximately 400 to 500 acre-feet per year. Most of this occurs in the vicinity of Sonoita-Elgin, while a smaller proportion may occur in the lower part of the Cienega Basin (Montgomery and Associates Inc. 2010).

Water use by domestic and stock wells has steadily increased in the basin. In 1980, approximately 630 domestic or stock wells were known to be in the Cienega Basin. By 1990, the number of domestic and stock wells had increased to more than 1,000, and by 2010, the number of domestic and stock wells had increased to more than 1,800 (Arizona Department of Water Resources 2011c). Many of these wells are considered to be exempt wells, which typically use less than 35 gallons per minute. Taken in combination, however, water use by these wells can be substantial. In addition to this, the Cienega Basin is located outside any active management area. Pumping within active management areas is regulated by the ADWR and is subject to issuance of groundwater rights. Because it is outside an active management area, even larger industrial, commercial, or municipal wells in the Cienega Basin can be drilled and pumped with little requirement, other than that the groundwater be put to beneficial use.

Many stock and domestic wells may not intersect the regional aquifer but rely on smaller, isolated pockets of alluvium or perched units not hydraulically connected with the regional system. Any individual well, unless directly adjacent to Cienega Creek, would have a negligible direct effect on stream flow. However, taken as a whole, the total amount of water withdrawn from wells within the Cienega Basin has to come from either aquifer storage or some other part of the basin water balance. Either option has the potential to cumulatively remove enough water from the aquifer to eventually affect perennial stream flow.

This potential is described in recent projections in the Cienega Creek basin, comparing population growth to stream flow depletion (Marshall et al. 2010). This work suggests that on Lower Cienega Creek, most demand projection scenarios indicate that by 2050 groundwater demand would exceed the base flow of Lower Cienega Creek. The same is not true for Upper Cienega Creek. Depending on specific water conservation scenarios, groundwater demand would remain the same or increase but would not exceed base flow. These types of comparisons of groundwater demand with base flow are not indications of direct impact but rather of the potential for increasing groundwater pumpage to occupy a larger and larger portion of the basin water balance. These comparisons also highlight the different conditions experienced by Upper and Lower Cienega Creek.

Surface Water Allocation

Arizona has a bifurcated water law system, which means that groundwater and surface water allocations are handled differently. While there are few restrictions on groundwater pumping within the Cienega Basin, there are significant restrictions on the allocation and use of surface waters.
All surface water use in Arizona requires a valid surface water right. Certificated water rights are those that have been perfected, and those surface water rights are superior to all other surface water rights with a later priority date but junior to all rights with an earlier (older) priority date. On Cienega Creek, several downstream certificated water rights are currently diverted at Pantano Dam and have priority dates senior to all other surface water rights on Cienega Creek. The presence of these senior certificated water rights effectively prevents further allocation of water along Cienega Creek; therefore, surface water use is unlikely to continue to grow in the way that groundwater pumpage increases over time. The senior certificated water rights are also those that are to be severed and transferred to serve as instream flow rights on Upper Cienega Creek (see mitigation measure FS-SSR-01 in Appendix B).

Overall Effect on Predictions

The purpose of this discussion preceding the analysis of effects on perennial stream flow is to highlight that in addition to the uncertainty contained in the analysis itself, there are other exacerbating factors in the watershed or groundwater basin that are likely to shift the underlying baseline conditions and therefore add another layer of uncertainty. In all cases discussed above, while specific effects may vary widely (for instance between Lower Cienega Creek and Upper Cienega Creek), the overall trend is negative. Climate change is likely to reduce water availability throughout the desert Southwest, although exactly how this would manifest is not predictable on a site-specific basis. Upper Cienega Creek may be somewhat shielded from drastic responses to drought, while Lower Cienega Creek reacts more quickly and negatively, but this very stability may mean that there is a greater reliance of Upper Cienega Creek on the regional aquifer and therefore a greater risk that any drawdown occurring in the aquifer due to the mine would have negative effects. Increased population growth and associated pumpage in the basin, while it is not clear exactly where it would occur or how much would occur, would become an increasing component of the available water balance. In the long term, these effects would likely spread throughout the basin.

If these current trends continue, there is little doubt that the desert Southwest, the greater Tucson area, and the Cienega Creek basin will experience severe water shortages at some unknown point in the future. Should such a situation occur, evaporation from the Rosemont Copper mine pit lake would be one of many factors in groundwater drawdown and related surface water effects in the Cienega Creek basin.

Predicted Effects on Empire Gulch Stream Flow

Portions of Empire Gulch are perennial or intermittent downstream of Empire Ranch and the nearby springs (titled Upper Empire Gulch springs in table 109). No surface disturbance from mining facilities is located within the Empire Gulch watershed; therefore, in assessing potential changes to stream flow, only the possible contribution of flow from the regional groundwater system is considered. An estimated 3 miles of Empire Gulch could be affected by hydrologic changes; this represents the reach of Empire Gulch roughly from the Upper Empire Gulch springs to the confluence with Cienega Creek.

All three groundwater flow models predict changes in groundwater levels in the vicinity of the Upper Empire Gulch springs (Montgomery and Associates Inc. 2010; Myers 2008; Tetra Tech 2010g). In all cases, the groundwater drawdown modeled to occur to Empire Gulch is less than that near the mine site but larger than that experienced along Cienega Creek, as shown in tables 59 through 64 of the "Groundwater Quantity" resource section of this chapter.

Level of Uncertainty for Empire Gulch

The levels of drawdown assessed for the near term in Empire Gulch are beyond the ability of the models to accurately predict and have a high level of uncertainty. Some of the levels of drawdown assessed for the long term in Empire Gulch are within the ability of the models to accurately predict and therefore have higher reliability. The long time frames and distance involved add a high level of uncertainty. Qualitatively, the trends for all three models suggest that drawdown could eventually occur; the impacts of that drawdown on stream flow could reasonably lie anywhere within the range of estimates provided. In addition, very little flow or channel data exist for Empire Gulch, and the applicability of the USGS stream gage data to represent Empire Gulch is highly uncertain. The stream gage data are more likely to be reasonable toward the confluence of Empire Gulch with Cienega Creek. Portions of Empire Gulch farther upstream are likely more sensitive and would experience greater impacts.

While the analysis contained in this section is quantitative, it reflects predicted impacts from relatively small amounts of groundwater drawdown, often fractions of a foot, that are occurring decades, hundreds, or even 1,000 years in the future. The conclusion of groundwater experts consulted by the Coronado is that such small drawdowns are beyond the ability of these groundwater models, or any groundwater model, to accurately predict (see the "Groundwater Quantity" resource section in chapter 3). It is important to understand that the detailed predictions contained in this section are meant to inform the decision and to show what could potentially happen if the model predictions were to occur as modeled; however, this does not change the overall uncertainty.

Analysis of impacts to BLM Federal reserved water rights associated with Empire Gulch is included in the "Indirect Impacts to Offsite Water Rights" part of the "Surface Water Quantity" resource section of this chapter. Water rights along Empire Gulch would likely be impacted by the changes described.

Near-Term Impacts

Existing Baseline Conditions— Under existing baseline conditions, dry conditions occur an average of 3 days per year (0.7 percent of the time), and dry or extremely low flow conditions (defined for this analysis as flow less than 0.2 foot) occur an average of 4 days per year (1.0 percent of the time).

Lowest Estimate— The lowest estimated drawdown at Empire Gulch 50 years after closure is less than 0.1 foot. If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Empire Gulch.

Estimate Based on Best-Fit Models— Based on the best-fit models, the estimated drawdowns at Empire Gulch 50 years after closure for the three models are less than 0.1 foot (Montgomery), 0.2 foot (Myers), and 0.5 foot (Tetra Tech). A drawdown of 0.2 foot would increase the risk of dry conditions occurring to 4 days per year (1.0 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 146 days per year (40.1 percent). A drawdown of 0.5 foot would increase the risk of dry conditions occurring to 283 days per year (77.5 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 352 days per year (96.3 percent).

Highest Estimate— The highest estimated drawdown at Empire Gulch 50 years after closure is 1.8 feet (Tetra Tech). A drawdown of 1.8 feet would increase the risk of dry conditions occurring to 361 days per year (98.9 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 362 days per year (99.1 percent).

Long-Term Impacts

Lowest Estimate— The lowest estimated drawdown at Empire Gulch 150 years after closure is 0.1 foot (Montgomery). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Empire Gulch. The lowest estimated drawdown at Empire Gulch 1,000 years after closure is 2.3 feet (Montgomery). A drawdown of 2.3 feet would increase the risk of dry conditions occurring to 363 days per year (99.4 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 363 days per year (99.5 percent).

Estimate Based on Best-Fit Models— Based on the best-fit models, the estimated drawdowns at Empire Gulch 150 years after closure for the three models are 0.3 foot (Montgomery and Myers) and 2.5 feet (Tetra Tech). A drawdown of 0.3 foot would increase the risk of dry conditions occurring to 32 days per year (8.8 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 283 days per year (77.5 percent). A drawdown of 2.5 feet would increase the risk of dry conditions occurring to 363 days per year (99.5 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 364 days per year (99.6 percent). The estimate drawdowns at Empire Gulch 1,000 years after closure for the three models are 3.3 feet

(Montgomery), 4.3 feet (Myers), and 6.0 feet (Tetra Tech). These drawdowns would increase the risk of dry conditions occurring to 364 to 365 days per year (99.7 to 100 percent).

Highest Estimate— The highest estimated drawdown at Empire Gulch 150 years after closure is 5.0 feet (Tetra Tech). The highest estimated drawdown at Empire Gulch 1,000 years after closure is 6.0 feet (Tetra Tech). Either of these drawdowns would increase the risk of dry conditions occurring to 365 days per year (100 percent).

Predicted Effects on Upper Cienega Creek Stream Flow

With respect to Upper Cienega Creek (Cienega Creek Reaches 1, 2, and 3, as shown in figure 67), no surface disturbance from mining facilities is located within the Upper Cienega Creek watershed upstream of the confluence with Davidson Canyon. Any contribution to perennial flows resulting from stormwater stored in shallow alluvial stream sediments would not be affected. Therefore, in assessing the potential changes to stream flow in Upper Cienega Creek, only the possible contribution to stream flow from the regional groundwater system is considered.

All three groundwater flow models predict changes in groundwater levels along Upper Cienega Creek (Montgomery and Associates Inc. 2010; Myers 2008; Tetra Tech 2010g). In all cases, the groundwater drawdown modeled to occur along Cienega Creek is less than that near the mine site, as shown in tables 59 through 64 of the "Groundwater Quantity" resource section of this chapter.

Upper Cienega Creek also receives surface water flow from Empire Gulch, and the potential for reduction in Empire Gulch stream flow could therefore also result in reductions in Upper Cienega Creek's stream flow as well. The percent contribution of Empire Gulch to Upper Cienega Creek has not been determined by fieldwork, but estimates of reductions have been incorporated into the analysis (SWCA Environmental Consultants 2013j).

Level of Uncertainty for Upper Cienega Creek

The levels of drawdown assessed for the near term and long term in Upper Cienega Creek are beyond the ability of the models to accurately predict and have a high level of uncertainty. The long time frames and distance involved add a high level of uncertainty. Qualitatively, the trends for all three models suggest that drawdown could eventually occur; the impacts of that drawdown on stream flow could reasonably lie anywhere within the range of estimates provided.

Public and cooperator comments suggest that small changes in groundwater level or flow, even if dwarfed by the natural background variability, have an additive effect that could impact riparian vegetation or aquatic species during times of drought or even seasonally. This possibility was disclosed in the DEIS and remains valid. Since the impact analysis makes use of the entire period of record on Upper Cienega Creek from 2001 to 2013, it incorporates these critical times of year. The daily depths of water for the USGS stream gage on Cienega Creek near Sonoita are shown in figure 70 for the period 2001 to 2013. Seasonally, the lowest mean monthly stream flows tend to occur in May and June. The lowest observed depth of water during this period was zero (June 2010), when the stream actually went dry for a period of 1 month. Clearly, a small change in stream flow could result in loss of surface flow during these drought periods.

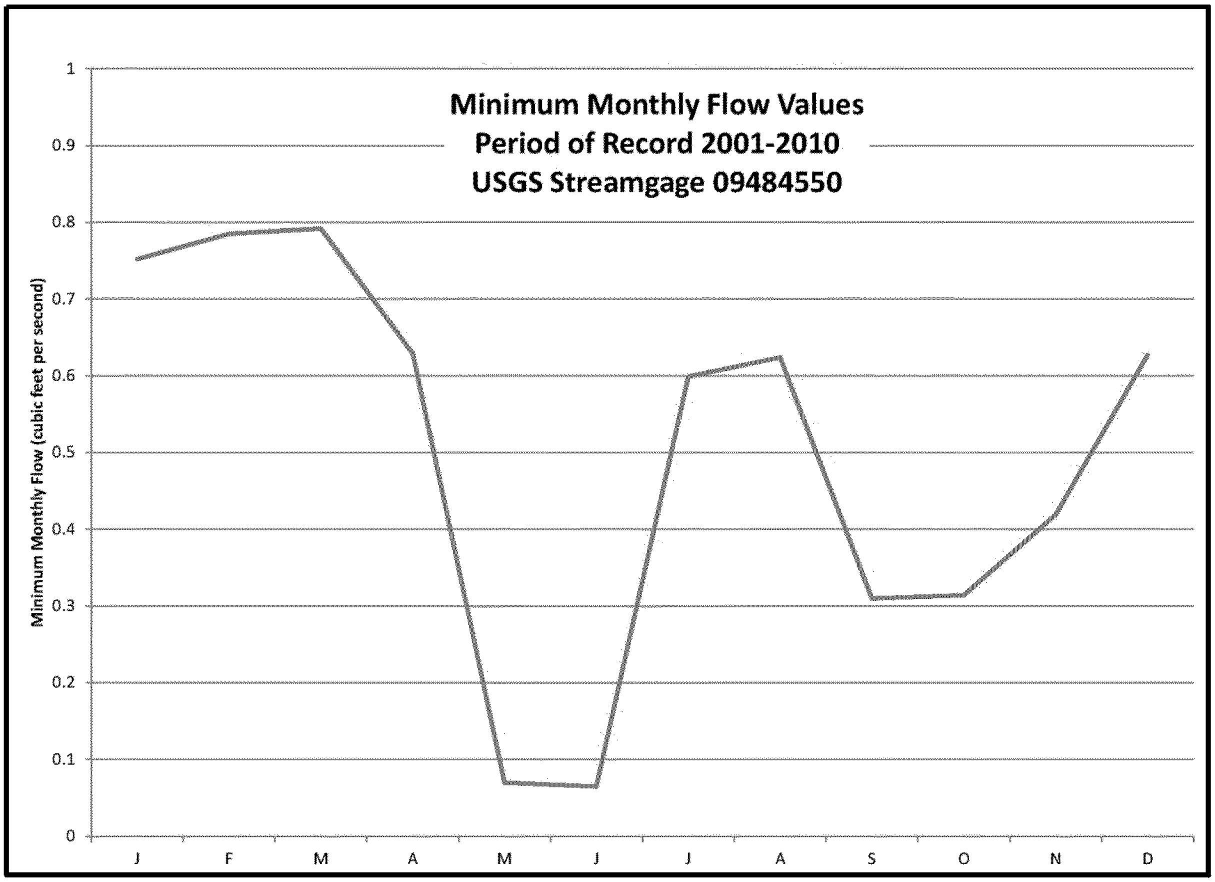

Figure 70. Depth of water in Upper Cienega Creek for period of record, 2001 to 2013

While the analysis contained in this section is quantitative, it reflects predicted impacts from relatively small amounts of groundwater drawdown, often fractions of a foot, that are occurring decades, hundreds, or even 1,000 years in the future. The conclusion of groundwater experts consulted by the Coronado is that such small drawdowns are beyond the ability of these groundwatermodels, or any groundwater model, to accurately predict (see the "Groundwater Quantity" resource section in chapter 3). It is important to understand that the detailed predictions contained in this section are meant to inform the decision and to show what could potentially happen if the model predictions were to occur as modeled; however, this does not change the overall uncertainty.

Near-Term Impacts

Existing Baseline Conditions— Under existing baseline conditions, dry conditions occur an average of 3 days per year (0.7 percent of the time), and dry or extremely low-flow conditions (defined for this analysis as flow less than 0.2 foot) occur an average of 4 days per year (1.0 percent of the time).

Lowest Estimate— The lowest estimated drawdown at Cienega Creek 50 years after closure is less than 0.1 foot (for both the Montgomery and Tetra Tech models). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Cienega Creek.

Estimate Based on Best-Fit Models— Based on the best-fit models, estimated drawdown at Cienega Creek 50 years after closure is less than 0.1 foot (for all three models). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Cienega Creek.

Highest Estimate— The highest estimated drawdown at Cienega Creek 50 years after closure is 0.15 foot (Tetra Tech), but loss of contributing stream flow from Empire Gulch would increase this to 0.20 foot. A drawdown of 0.2 foot would increase the risk of dry conditions occurring to 4 days per year (1.0 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 141 days per year (40.6 percent).

Long-Term Impacts

Lowest Estimate— The lowest estimated drawdown at Cienega Creek 150 years after closure is less than 0.1 foot (for both the Montgomery and Tetra Tech models). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Cienega Creek. The lowest estimated drawdown at Cienega Creek 1,000 years after closure is still less than 0.1 foot (Montgomery), but loss of contributing stream flow from Empire Gulch would increase this to 0.15 foot. A drawdown of 0.15 foot would increase the risk of dry conditions occurring to 3 days per year (0.9 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 88 days per year (24.2 percent).

Estimate Based on Best-Fit Models— Based on the best-fit models, the estimated drawdowns along Cienega Creek 150 years after closure for the three models are less than 0.1 foot (Montgomery and Myers), and 0.25 foot (Tetra Tech); however, loss of contributing stream flow from Empire Gulch would increase these drawdowns to 0.15 foot and 0.3 foot, respectively. A drawdown of 0.15 foot would increase the risk of dry conditions occurring to 3 days per year (0.9 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 88 days per year (24.2 percent). A drawdown of 0.3 foot would increase the risk of dry conditions occurring to 32 days per year (8.8 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 283 days per year (77.5 percent). The estimated drawdowns along Cienega Creek 1,000 years after closure for the three models are less than 0.1 foot (Montgomery), 0.2 foot (Myers), and 0.5 foot (Tetra Tech); however, loss of contributing stream flow from both Empire Gulch and Gardner Canyon would increase these drawdowns to 0.15 foot, 0.38 foot, and 0.68 foot, respectively. A drawdown of 0.15 foot would increase the risk of dry conditions occurring to 3 days per year (0.9 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 88 days per year (24.2 percent). A drawdown of 0.38 feet would increase the risk of dry conditions occurring to 125 days per year (34.1 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 339 days per year (92.8 percent). A drawdown of 0.68 foot would increase the risk of dry conditions occurring to 351 days per year (96.2 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 354 days per year (96.9 percent).

Highest Estimate— The highest estimated drawdown along Cienega Creek 150 years after closure is 0.35 foot (Tetra Tech), but loss of contributing stream flow from both Empire Gulch and Gardner Canyon would increase this to 0.53 foot. A drawdown of 0.53 foot would increase the risk of dry conditions occurring to 313 days per year (85.7 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 352 days per year (96.5 percent). The highest estimated drawdown along Cienega Creek 1,000 years after closure is 0.5 foot (Tetra Tech), but loss of contributing stream flow from both Empire Gulch and Gardner Canyon would increase this to 0.68 foot. A drawdown of 0.68 foot would increase the risk of dry conditions occurring to 351 days per year (96.2 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 354 days per year (96.9 percent).

Predicted Effects on Gardner Canyon Stream Flow

With respect to Gardner Canyon (Gardner Canyon Reach 2, as shown in figure 67), no surface disturbance from mining facilities would be located within the Upper Cienega Creek watershed upstream of the confluence with Davidson Canyon. Any contribution to perennial flows resulting from stormwater stored in shallow alluvial stream sediments would not be affected. Therefore, in assessing the potential changes to stream flow in Gardner Canyon, only the possible contribution to stream flow from the regional groundwater system is considered.

Groundwater drawdown modeled to occur at the confluence of Gardner Canyon and Cienega Creek is shown in tables 59 through 64 of the "Groundwater Quantity" resource section of this chapter.

Level of Uncertainty for Gardner Canyon

The levels of drawdown assessed for the near term and long term in Gardner Canyon are beyond the ability of the models to accurately predict and have a high level of uncertainty. The long time frames and distance involved add a high level of uncertainty. Qualitatively, the trends for all three models suggest that drawdown could eventually occur; the impacts of that drawdown on stream flow could reasonably lie anywhere within the range of estimates provided. In addition, no flow or channel data exist for Gardner Canyon, and the applicability of the USGS stream gage data to represent Gardner Canyon is highly uncertain. The stream gage data are more likely to be reasonable toward the confluence of Gardner Canyon with Cienega Creek. Portions of Gardner Canyon farther upstream are likely more sensitive and would experience greater impacts.

While the analysis contained in this section is quantitative, it reflects predicted impacts from relatively small amounts of groundwater drawdown, often fractions of a foot, that are occurring decades, hundreds, or even 1,000 years in the future. The conclusion of groundwater experts consulted by the Coronado is that such small drawdowns are beyond the ability of these groundwater models, or any groundwater model, to accurately predict (see the "Groundwater Quantity" resource section in chapter 3). It is important to understand that the detailed predictions contained in this section are meant to inform the decision and to show what could potentially happen if the model predictions were to occur as modeled; however, this does not change the overall uncertainty.

Near-Term Impacts

Existing Baseline Conditions— Under existing baseline conditions, dry conditions occur an average of 3 days per year (0.7 percent of the time), and dry or extremely low-flow conditions (defined for this analysis as flow less than 0.2 foot) occur an average of 4 days per year (1.0 percent of the time).

Lowest Estimate— The lowest estimated drawdown at Gardner Canyon 50 years after closure is less than 0.1 foot (for all three models). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Gardner Canyon.

Estimate Based on Best-Fit Models— Based on the best-fit models, the estimated drawdown at Gardner Canyon 50 years after closure is less than 0.1 foot (for all three models). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Gardner Canyon.

Highest Estimate— The highest estimated drawdown at Gardner Canyon 50 years after closure is 0.15 foot (Tetra Tech). A drawdown of 0.15 foot would increase the risk of dry conditions occurring to 3 days per year (0.9 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 88 days per year (24.2 percent).

Long-Term Impacts

Lowest Estimate— The lowest estimated drawdown at Gardner Canyon 150 years after closure is less than 0.1 foot (for the Montgomery model). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Gardner Canyon. The lowest estimated drawdown at Gardner Canyon 1,000 years after closure is still less than 0.1 foot (Montgomery). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Gardner Canyon.

Estimate Based on Best-Fit Models— Based on the best-fit models, the estimated drawdowns at Gardner Canyon 150 years after closure are less than 0.1 foot (Montgomery), 0.1 foot (Myers), and 0.2 foot (Tetra Tech). A drawdown of 0.2 foot would increase the risk of dry conditions occurring to 4 days per year (1.0 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 146 days per year (40.1 percent). The estimated drawdowns at Gardner Canyon 1,000 years after closure are less than 0.1 foot (Montgomery), 0.5 foot (Tetra Tech), and 2.2 feet (Myers). A drawdown of 0.5 foot would increase the risk of dry conditions occurring to 283 days per year (77.5 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 352 days per year (96.3 percent). A drawdown of 2.2 feet would increase the risk of dry conditions or extremely low-flow conditions occurring to 363 days per year (99.4 percent).

Highest Estimate— The highest estimated drawdown at Gardner Canyon 150 years after closure is 0.4 foot (Montgomery). A drawdown of 0.4 foot would increase the risk of dry conditions occurring to 146 days per year (40.1 percent) and would increase the risk of dry or extremely low-flow conditions occurring to 349 days per year (95.5 percent). The highest estimated drawdown at Gardner Canyon by 1,000 years after closure is 2.2 feet. A drawdown of 2.2 feet would increase the risk of dry conditions or extremely low-flow conditions occurring to 363 days per year (99.4 percent).

Predicted Effect on Davidson Canyon Stream Flow

Potential impacts to stream flow in lower Davidson Canyon (Davidson Canyon Reach 4, as shown in figure 67) are handled in two separate ways. The available evidence suggests that the stream flow and springs arising in lower Davidson Canyon derive their water from a localized source, specifically storm flow stored in shallow alluvial stream sediments. Impacts have been analyzed assuming this source of water for lower Davidson Canyon. However, there is uncertainty with this interpretation. Therefore, impacts to Davidson Canyon are also analyzed under the assumption that the stream flow and springs arising in lower Davidson Canyon are connected to the regional aquifer, which would be impacted by the mine pit.

Potential Impacts Based on a Shallow Alluvial Source

A detailed hydrogeologic analysis of Davidson Canyon was conducted by Tetra Tech (2010a) specifically to assess potential impacts to stream flow and springs within Davidson Canyon. Rather than using modeling, this study focused on assessing observed field data in order to determine likely impacts to perennial stream flow in lower Davidson Canyon (Tetra Tech 2010a). Based on water quality data, geological mapping and reconnaissance, observed groundwater levels, and observed flow data, Tetra Tech (2010a) drew several conclusions about the source of surface flow that begins at Reach 2 Spring and persists intermittently to the confluence of Cienega Creek. The Tetra Tech (2010a) report concludes that it is likely that Reach 2 Spring (as well as Escondido Spring, which is closer to the confluence with Cienega Creek) derives its water from ephemeral storm flows stored in the shallow alluvial stream sediments, which are then forced to the surface by bedrock constrictions of the stream channel, and that these springs are not likely connected to the regional aquifer that would be impacted by the mine pit.

These conclusions are based on several lines of evidence. Geological conditions were observed that would be conducive to forcing shallow alluvial water to the surface in the locations of Reach 2 and Escondido Springs. In addition, isotope signatures of water from Reach 2 Spring and Escondido Spring both reflect the influence of summer precipitation, in contrast to wells in the regional aquifer, which reflect the influence of winter precipitation. Finally, this stretch of Davidson Canyon has actually been dry during the past few years, rather than being supported by perennial flow, as would be expected from a more constant regional groundwater source.

After publication of the DEIS, the Coronado undertook further investigation of impacts to Outstanding Arizona Waters, including those of Davidson Canyon, and specifically tasked SRK Consulting to review and weigh the evidence and determine the most likely source of water for flow in Davidson Canyon (Garrett 2012h; Ugorets, Cope, and Hoag 2012). SRK Consulting concluded that while some of the available evidence was anecdotal and less than certain, the available information suggests that there is no connection between the Davidson Canyon springs and the regional aquifer. Primary lines of evidence for this conclusion included observed groundwater levels in a well located in lower Davidson Canyon and completed in bedrock, observations of Reach 2 Spring during sequential field visits, and isotopic signatures of the spring water (Ugorets, Cope, and Hoag 2012).

These studies suggest that drawdown in the regional groundwater is unlikely to affect the springs in lower Davidson Canyon. Conversely, these studies also suggest that reductions in surface flow have the potential to reduce recharge to the shallow alluvial aquifer in lower Davidson Canyon and thereby impact Reach 2 and Escondido Spring and potential base flow between those springs and Cienega Creek. Unlike for Upper Cienega Creek, the proposed surface disturbance by the mine within the headwaters of the Davidson Canyon watershed would reduce surface water flows.

Modeling of changes in ephemeral surface runoff as a result of the mine activities has been conducted (Krizek 2010a, 2010b, 2010c, 2010d; Zeller 2012). Runoff in Barrel Canyon (at SR 83) would decrease by approximately 17 to 46 percent, depending on the alternative, as a result of capture of runoff by mine facilities. This change in stream flow would decrease with distance downstream (Zeller 2011a). Estimated reductions in surface flow in lower Davidson Canyon (approximately 12 miles downstream) range from 4.3 to 11.5 percent (SWCA Environmental Consultants 2012d).

The surface water hydrology of the watershed suggests that modeling of reduced surface flows in lower Davidson Canyon is likely overestimated. Specifically, the estimates above are based on regression equations in an ideal watershed without consideration of channel losses. In reality, in order to recharge the stream aquifer in lower Davidson Canyon, storm flows from Barrel Canyon need to travel downstream approximately 12 miles in an ephemeral stream channel (desert wash) composed of pockets of highly transmissive sediments. Multiple studies have estimated stream losses in ephemeral stream channels, with a range between 0.3 acre-foot and more than 17,000 acre-feet of water lost per mile of ephemeral channel (Cataldo et al. 2004). Qualitatively, given the travel distance from Barrel Canyon, the recharge in lower Davidson Canyon is more likely to derive from closer tributaries, although certainly during larger flow events, contribution from Barrel Canyon could occur.

In summary, the weight of the available evidence suggests that lower Davidson Canyon is not hydraulically connected to the regional aquifer that would be impacted by the pit dewatering. Changes in surface flow and, therefore, to the recharge to shallow alluvial aquifers are possible as a result of disturbance by the mine and the removal of portions of the watershed upstream. The effect of the reduction in surface flow is estimated and could reduce storm flows by 4.3 to 11.5 percent, depending on alternative, but this effect on recharge is likely to be overestimated, with the contribution being less owing to the distance downstream of the project area and substantial channel losses. Predictions of loss of recharge to the shallow alluvial aquifer have a high level of uncertainty because of the nature of the channels and the relatively great distance between the impacts from the proposed mine and lower Davidson Canyon.

Comments from cooperating agencies have suggested that the distance between the mine site and lower Davidson Canyon is not pertinent, as any losses to the shallow alluvial aquifer in Barrel Canyon and Davidson Canyon would eventually flow into lower Davidson Canyon anyway as subflow in the shallow alluvial aquifer. This is not a realistic scenario based on the actual characteristics of the channel. There are substantial stretches of stream channel with rock present at the surface and no alluvium at all (Patterson and Annandale 2012). The stream channel along Barrel Canyon and Davidson Canyon is not a continuous thread of alluvium, but rather linear pockets of alluvium separated by reaches with little or no alluvial material. This is a common occurrence in southern Arizona.

The fate of stormwater infiltrating into these pockets of alluvium would be varied. Some of the stormwater would be stored as soil moisture in the channel or channel banks and would not infiltrate to any shallow water table. Some of the stormwater would be used by riparian vegetation, either drawing directly from a shallow water table (typical with hydroriparian vegetation like cottonwoods or willows) or from stored soil moisture (typical with xeroriparian vegetation). This stormwater would be transpired and lost to the watershed, although for a beneficial use. Some stormwater would infiltrate through alluvial materials and fractures in the bedrock, recharging the regional aquifer. It is also likely that the regional aquifer could contribute water to shallow alluvial materials in the same manner. Some stormwater would flow subsurface downstream and be forced to the surface by constrictions in the stream channel; indeed, this is likely the case for Barrel Spring in Barrel Canyon and for Reach 2 and Escondido Springs in lower Davidson Canyon.

The studies cited in the section (Cataldo et al. 2004) have not been used to try to quantify the stormwater losses. This would not be appropriate, given that these studies are not all applicable to the geology along Barrel Canyon and Davidson Canyon and that the uncertainty and range of results is so great. These studies are cited solely as an indication that stormwater losses in ephemeral channels are a physical reality and can be substantial. The effect on surface flows in lower Davidson Canyon, assuming no transmission losses at all, ranges from 4.3 to 11.5 percent. This effect should be considered a maximum possible loss to shallow alluvial aquifers in lower Davidson Canyon, with actual losses likely to be much lower.

Potential Impacts Based on a Regional Source

If the assumption that the springs in lower Davidson Canyon are not connected to the regional aquifer is incorrect, an assessment similar to that conducted for Upper Cienega Creek, Empire Gulch, and Gardner Canyon can be used to assess potential impacts to Davidson Canyon.

Level of Uncertainty for Davidson Canyon—The levels of drawdown assessed for both the near term and long term in Davidson Canyon are beyond the ability of the models to accurately predict and have a high level of uncertainty. The long time frames and distance involved also add a high level of uncertainty. Qualitatively, the trends for the models suggest that drawdown could eventually occur; the impacts of that drawdown on stream flow could reasonably lie anywhere within the range of estimates provided, if the springs in lower Davidson Canyon are in connection with the regional aquifer.

While the analysis contained in this section is quantitative, it reflects predicted impacts from relatively small amounts of groundwater drawdown, often fractions of a foot, that are occurring decades, hundreds, or even 1,000 years in the future. The conclusion of groundwater experts consulted by the Coronado is that such small drawdowns are beyond the ability of these groundwater models, or any groundwater model, to accurately predict (see the "Groundwater Quantity" resource section in chapter 3). It is important to understand that the detailed predictions contained in this section are meant to inform the decision and to show what could potentially happen if the model predictions were to occur as modeled; however, this does not change the overall uncertainty.

Near-Term Impacts—

Lowest Estimate – The lowest estimated drawdown at Reach 2 Spring in Davidson Canyon 50 years after closure is less than 0.1 foot (for both the Montgomery and Tetra Tech models). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Davidson Canyon.

Estimate Based on Best-Fit Models – Based on the best-fit models, the estimated drawdowns at Reach 2 Spring 50 years after closure are 0.1 foot or less (for both the Montgomery and Tetra Tech models). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Davidson Canyon.

Highest Estimate – The highest estimated drawdown at Reach 2 Spring 50 years after closure is 1.5 foot (Montgomery). If occurring and if Reach 2 Spring is in connection with the regional aquifer, in general this amount of drawdown would likely cause widespread absence of surface flow for large portions of the year.

Long-Term Impacts—

Lowest Estimate – The lowest estimated drawdown at Reach 2 Spring up to 1,000 years after closure is less than 0.1 foot (Montgomery). If occurring, in general this amount of drawdown is unlikely to result in any noticeable loss of surface flow in Davidson Canyon.

Estimate Based on Best-Fit Models – Based on the best-fit models, the estimated drawdowns at Reach 2 Spring 150 years after closure are less than 0.1 foot (Tetra Tech) and 0.3 foot (Montgomery). If occurring and if Reach 2 Spring is in connection with the regional aquifer, in general this amount of drawdown would noticeably reduce stream flows but would not result in widespread absence of flow. This amount of drawdown would potentially cause a reduction in the length of wet sections or even drying of some sections. Based on the best-fit models, the estimated drawdowns at Reach 2 Spring 1,000 years after closure are 0.3 foot (Tetra Tech) and 1.0 feet (Montgomery). If occurring and if Reach 2 Spring is in connection with the regional aquifer, in general this amount of drawdown would likely cause widespread absence of surface flow for large portions of the year.

Highest Estimate – The highest estimated drawdown at Reach 2 Spring 150 years after closure is 3.0 feet, reaching 4.0 feet 1,000 years after closure (Montgomery). If occurring and if Reach 2 Spring is in connection with the regional aquifer, in general this amount of drawdown would likely cause widespread absence of surface flow for large portions of the year.

Predicted Effects on Lower Cienega Creek Perennial Stream Flow

The potential for reduction of perennial stream flow on Lower Cienega Creek (Cienega Creek Reaches 4 and 5, as shown in figure 67) would be driven by two factors. Reduction of contribution from Davidson Canyon could affect Reach 5, and reduction of contribution from Upper Cienega Creek could affect Reaches 4 and 5.

Based on the analysis of Davidson Canyon presented above, the same conclusions would apply to Lower Cienega Creek below the confluence with Davidson Canyon. Effects on Cienega Creek due to surface flow reduction would be minimal (see the "Effect on Groundwater Discharge from Davidson Canyon" part of the "Groundwater Quantity" resource section of this chapter).

The difference in hydrology between Upper Cienega Creek and Lower Cienega Creek makes it difficult to determine how changes in Upper Cienega Creek would propagate downstream. There is a geographic disconnect between the typically perennial sections of Upper Cienega Creek and Lower Cienega Creek. Over the past decade, Lower Cienega Creek has experienced negative stream flow trends due in great part to the ongoing drought. However, over this same time period, Upper Cienega Creek has exhibited relatively little change in summer or winter base flow. This does not indicate that Upper Cienega Creek is not an important contributor to flow to Lower Cienega Creek; rather, it suggests that Lower Cienega Creek also relies on other sources of water that are more sensitive to drought.

For predicting impacts, the most conservative approach is to assume that any changes on Upper Cienega Creek driven by groundwater drawdown would propagate to Lower Cienega Creek as well, and that similar changes in perennial stream flow would be experienced downstream as well as upstream.

Summary of Impacts to Stream flow

To summarize impacts to stream flow, it is useful to translate the increase in risk of drying to the definitions of perennial, intermittent, and ephemeral streams. A perennial stream exhibits flow in response to groundwater most of the year, although dry spells do occur, as happened in June 2010 on Upper Cienega Creek. Slight increases in risk of drying, for instance from an average of 3 days per year to 4 days per year, would not shift the stream from perennial to intermittent. However, increases in the risk of drying that suggest dry spells would occur with regularity instead of infrequently could shift the stream from perennial to intermittent. For the purposes of this analysis, an increase in risk of drying to anything more than 30 days per year suggests that dry spells would occur regularly, likely during low summer flows in May and June and therefore would shift the stream from perennial to intermittent. Ephemeral streams flow only in response to storms, which occur approximately 15 days per year; therefore, an increase in risk of drying that extends longer than about 350 days per year would be considered to shift the stream from perennial or intermittent to ephemeral. As noted earlier, drawdown happens steadily over time, and impacts would be present at times other than the time frames of 50, 150, and 1,000 years after closure.

- For Empire Gulch, the lowest estimates of drawdown would not change the perennial nature of the stream up to 150 years after closure, but the stream would be ephemeral by 1,000 years after closure.
- For Empire Gulch, estimates of drawdown for best-fit models are mixed. Two of the best-fit models indicate that the stream would shift from perennial to intermittent by150 years after closure. One of the best-fit models indicates that the stream would be intermittent by 50 years after closure and ephemeral by 150 years after closure. All three best-fit models indicate that the stream would be ephemeral by 1,000 years after closure.
- For Empire Gulch, the highest estimates of drawdown indicate a change from perennial to ephemeral stream by 50 years after closure.
- For Upper Cienega Creek, the lowest estimates of drawdown would not change the perennial nature of the stream, even up to 1,000 years after closure.
- For Upper Cienega Creek, estimates of drawdown for best-fit models are mixed. One best-fit model indicates that the perennial nature of the stream would not change even up to 1,000 years after closure. One best-fit model indicates the stream would remain perennial up through 150 years after closure but would gradually become intermittent by 1,000 years after closure. The third best-fit model indicates the stream would remain perennial up through 50 years after closure, would gradually become intermittent by 150 years after closure with dry periods averaging 1 month per year, and would become ephemeral by 1,000 years after closure.
- For Upper Cienega Creek, the highest estimates of drawdown would not change the perennial nature of the stream up through 50 years after closure, but the stream would gradually become intermittent by 150 years after closure and would become ephemeral by 1,000 years after closure.
- For Lower Cienega Creek, the same impacts experienced on Upper Cienega Creek are assumed to propagate downstream and be experienced on Lower Cienega Creek as well.
- For Gardner Canyon, the lowest estimates of drawdown would not change the perennial nature of the stream, even up to 1,000 years after closure.
- For Gardner Canyon, estimates of drawdown for best-fit models would not change the perennial nature of the stream up through 150 years after closure. At 1,000 years after closure, results are mixed, with one model indicating a perennial stream, one model indicating an intermittent stream, and one model indicating an ephemeral stream.
- For Gardner Canyon, the highest estimates of drawdown would not change the perennial nature of the stream up through 50 years after closure. The stream would gradually become intermittent by 150 years after closure, and by 1,000 years after closure, the stream would be ephemeral.
- The weight of the available evidence suggests that lower Davidson Canyon is not hydraulically connected to the regional aquifer that would be impacted by the pit dewatering. Changes in surface flow and, therefore, to the recharge to shallow alluvial aquifers are possible as a result of disturbance and the removal of portions of the watershed upstream by mining activities. There would be an estimated reduction in surface flow of 4.3 to 11.5 percent, depending on the alternative, but a similar effect on recharge is likely to be overpredicted because of the distance downstream of the project area and the high channel transmission losses.

Indirect Effect on Water Quality due to Stream Flow Depletion

As noted, the risk of drying (i.e., shifting the nature of flow from perennial to intermittent or ephemeral) is only one of the negative outcomes that can occur from impact of drawdown along Upper Cienega Creek, Empire Gulch, and Gardner Canyon. Extremely low-flow conditions can also have an effect, primarily due to potential changes in water quality.

Under existing conditions, Upper Cienega Creek seasonally experiences depths of flow as low as about 0.3 foot in May and June. As the amount of flow in the stream decreases, water temperatures can increase, dissolved oxygen can become depleted, nutrient loads can become more concentrated, and the assimilative capacity of the stream can be reduced. The exact amount of change in water quality cannot be easily quantified, but down to depths of 0.3 foot, the water quality would remain within the seasonal variation experienced under existing conditions.

The risk of extremely low-flow conditions (defined for this analysis as 0.2 foot or less) has been quantified. While the analysis contained in this section is quantitative, it reflects predicted impacts from relatively small amounts of groundwater drawdown, often fractions of a foot, that are occurring decades, hundreds, or even 1,000 years in the future. The conclusion of groundwater experts consulted by the Coronado is that such small drawdowns are beyond the ability of these groundwater models, or any groundwater model, to accurately predict (see the "Groundwater Quantity" resource section in chapter 3). It is important to understand that the detailed predictions contained in this section are meant to inform the decision and to show what could potentially happen if the model predictions were to occur as modeled; however, this does not change the overall uncertainty.

Under these conditions, water quality would continue to deteriorate and would reach levels not typically experienced in the stream. Note that the impacts described below do not include any periods when the stream has been predicted to be ephemeral (see "Effects on Perennial Stream flow" part of this resource section).

- For Empire Gulch, the lowest estimates of drawdown indicate that the risk of extremely low-flow conditions and degraded water quality occurring does not change.
- For Empire Gulch, estimates of drawdown for best-fit models mostly indicate a substantial increase in the risk of extremely low-flow conditions and degraded water quality starting as early as 50 years after closure, increasing from an average of 4 days per year to at least 146 days per year, although one model indicates no changes at 50 years after closure. By 150 years after closure, substantial portions of the year (283 days per year) would be experiencing low-flow conditions and degraded water quality.
- For Upper Cienega Creek, the lowest estimates of drawdown indicate that the risk of extremely low-flow conditions and degraded water quality occurring does not change up to 150 years after closure. At 1,000 years after closure, the risk increases somewhat from an average of 4 days per year under existing conditions to 88 days per year. These days would occur seasonally during the summer.
- For Upper Cienega Creek, estimates of drawdown for best-fit models indicate that the risk of extremely low-flow conditions and degraded water quality occurring does not change up to 50 years after closure. At 150 years after closure, the risk increases from an average of 4 days per year under existing conditions to anywhere from 88 to 283 days per year. At 1,000 years after closure, the risk increases to anywhere from 88 days to nearly the whole year (339 days).

- For Upper Cienega Creek, the highest estimates of drawdown indicate a substantial increase in the risk of extremely low-flow conditions and degraded water quality starting as early as 50 years after closure, increasing from an average of 4 days per year to 146 days per year, and eventually to nearly the whole year (352 days) by 150 years after closure.
- For Gardner Canyon, the lowest estimates of drawdown indicate that the risk of extremely low-flow conditions and degraded water quality occurring does not change.
- For Gardner Canyon, estimates of drawdown for best-fit models indicate that the risk of extremely low-flow conditions and degraded water quality occurring does not change up to 50 years after closure. At 150 years after closure results are mixed, indicating anywhere from no change in risk up to an increase to146 days of extremely low-flow conditions and degraded water quality. At 1,000 years after closure results remain mixed, indicating anywhere from no change in risk up to nearly the whole year (352 days).
- For Gardner Canyon, the highest estimates of drawdown indicate an increase in the risk of extremely low-flow conditions and degraded water quality starting as early as 50 years after closure, increasing from an average of 4 days per year to 88 days per year, and eventually to nearly the whole year (349 days) by 150 years after closure.

Indirect Effect on Riparian Vegetation

The direct disturbance of xeroriparian vegetation present in onsite washes varies by alternative and is presented by alternative later in this section. This section addresses the indirect effects on riparian vegetation beyond the surface disturbance within the project area, owing either to changes in stormwater runoff or to changes in groundwater levels. The analysis contained in this section depends on the quantitative assessment provided earlier in this chapter. That assessment was based on predicted impacts from relatively small amounts of groundwater drawdown, often fractions of a foot, that are occurring decades, hundreds, or even 1,000 years in the future. The conclusion of groundwater experts consulted by the Coronado is that such small drawdowns are beyond the ability of these groundwater models, or any groundwater model, to accurately predict (see the "Groundwater Quantity" resource section in chapter 3). It is important to understand that the detailed predictions contained in this section are meant to inform the decision and to show what could potentially happen if the model predictions were to occur as modeled; however, this does not change the overall uncertainty.

Predicted Effect on Riparian Vegetation in Empire Gulch

Hydroriparian habitat is present. An estimated 407 acres has been mapped as hydroriparian habitat and may be affected. Xeroriparian habitat is also present but is unlikely to be affected.

Lowest Estimate

In the near term, the lower estimates of groundwater drawdown (0.1 foot) would not be likely to result in any changes to riparian vegetation or impacts to aquatic vegetation. In the long term, the lower estimates of groundwater drawdown (2.3 feet) would be unlikely to cause widespread mortality or transition from hydroriparian to xeroriparian habitat since many of these species can still access water several feet below ground surface. However, cottonwood/willow forest would experience stress due to deeper groundwater availability, including a decrease in canopy height and vegetation volume. While total conversion from a hydroriparian to a xeroriparian corridor is unlikely, there is likely to be contraction of the hydroriparian area, with conversion occurring at the transitional margins of the habitat. Herbaceous perennials (bulrush, cattail, grasses) and annuals would experience mortality and reduced abundance. In the long term, wetland complexes within the hydroriparian zone would likely experience drying and mortality of obligate wetland plants, and aquatic vegetation would experience widespread mortality.

Estimate Based on Best-Fit Models

In the near term, the estimates of groundwater drawdown based on the best-fit models (0.2 foot) would not be likely to result in any changes to riparian vegetation. In the long term, the estimates of groundwater drawdown based on the best-fit models (4.3 feet) would contribute to mortality and a transition from hydroriparian to xeroriparian habitat. Cottonwood/willow forest would experience increased mortality rates and a decrease in canopy height and vegetation volume, and the transition from cottonwood/willow forest to deeper rooted tamarisk or mesquite would be encouraged. Herbaceous perennials (bulrush, cattail, grasses) and annuals would experience mortality and reduced abundance. In the long term, wetland complexes within the hydroriparian zone would likely experience drying and mortality of obligate wetland plants, and aquatic vegetation would experience widespread mortality.

Highest Estimate

In the near term, the higher estimate of groundwater drawdown (1.8 feet) would be unlikely to cause widespread mortality or transition from hydroriparian to xeroriparian habitat, but cottonwood/willow forest would experience stress due to deeper groundwater availability, including a decrease in canopy height and vegetation volume. While total conversion from a hydroriparian to a xeroriparian corridor is unlikely, there is likely to be contraction of the hydroriparian area, with conversion occurring at the transitional margins of the habitat. Herbaceous perennials (bulrush, cattail, grasses) and annuals would experience mortality and reduced abundance. In the long term, the higher estimate of groundwater drawdown (6.0 feet) would contribute to mortality and a transition from hydroriparian to xeroriparian habitat. Cottonwood/willow forest would experience increased mortality rates and a decrease in canopy height and vegetation volume, and the transition from cottonwood/willow forest to deeper rooted tamarisk or mesquite would be encouraged. Herbaceous perennials (bulrush, cattail, grasses) and annuals would experience mortality and reduced abundance. In the near term and long term, wetland complexes within the hydroriparian zone would likely experience drying and mortality of obligate wetland plants, and aquatic vegetation would experience widespread mortality.

Predicted Effect on Riparian Vegetation in Cienega Creek (Reaches 1 through 5)

Lowest Estimate

The lower estimates of groundwater drawdown (less than 0.1 foot) would not be likely to result in any changes to riparian vegetation, even up through 1,000 years after mine closure.

Estimate Based on Best-Fit Models

The estimates of groundwater drawdown based on the best-fit models (up to 0.5 foot) would not be likely to result in any changes to riparian vegetation, even up through 1,000 years after mine closure.

Highest Estimate

The higher estimate of groundwater drawdown (up to 0.8 foot) would not be likely to result in widespread changes to riparian vegetation, even up through 1,000 years after mine closure. However, while total conversion from a hydroriparian to a xeroriparian corridor is unlikely, there is likely to be contraction of the hydroriparian area, with conversion occurring at the transitional margins of the habitat.

Predicted Effect on Riparian Vegetation in Gardner Canyon (Reaches 1 and 2)

Lowest Estimate

The lower estimates of groundwater drawdown (less than 0.1 foot) would not be likely to result in any changes to riparian vegetation, even up through 1,000 years after mine closure.

Estimates Based on Best-Fit Models

The estimates of groundwater drawdown based on best-fit models (up to 0.5 foot) would not be likely to result in any changes to riparian vegetation, even up through 1,000 years after mine closure.

Highest Estimate

The higher estimate of groundwater drawdown (up to 0.8 foot) would not be likely to result in widespread changes to riparian vegetation, even up through 1,000 years after mine closure. However, while total conversion from a hydroriparian to a xeroriparian corridor is unlikely, there is likely to be contraction of the hydroriparian area, with conversion occurring at the transitional margins of the habitat.

Predicted Effect on Riparian Vegetation in Davidson Canyon (Reach 1)

Predicted Hydrologic Changes

This reach of Davidson Canyon is upstream of the confluence with Barrel Canyon. No changes in surface flow are expected to occur.

Drawdown in the regional aquifer is predicted to range from 10 to 100 feet in this location; however, this reach of Davidson Canyon is primarily xeroriparian, with pockets of mesoriparian vegetation. Some of this vegetation may rely on groundwater but would most likely be relying on shallow alluvial groundwater, as there are no indications of perennial or intermittent flow in this reach and no extensive hydroriparian or mesoriparian galleries. No change would be expected to occur with shallow alluvial groundwater.

Expected Effects on Riparian Vegetation

No areas of riparian vegetation associated with this reach of Davidson Canyon would be expected to be impacted based on the hydrologic changes described above.

Predicted Effect on Riparian Vegetation in Davidson Canyon (Reach 2)

Predicted Hydrologic Changes

As with Reach 1 of Davidson Canyon, drawdown in the regional aquifer is predicted (ranging from 5 to 10 feet). However, there are no indications of connection of this reach to regional groundwater.

On the other hand, changes in surface flow can be estimated to occur along this reach and would range from 13.1 to 34.8 percent (SWCA Environmental Consultants 2012d). This reach is close enough to the mine disturbance in Barrel Canyon that this prediction has a relatively high level of certainty. This change in surface flow may reduce the amount of stormwater recharging the shallow alluvial aquifer and therefore the amount available for riparian habitat.

Expected Effects on Riparian Vegetation

This reach of Davidson Canyon is characterized as xeroriparian habitat with pockets of mesoriparian habitat; these pockets of mesoriparian habitat may be supported by shallow alluvial groundwater. Pockets of mesoriparian habitat may experience reduced recruitment, increased mortality rates, decreased canopy height and vegetation volume, and potentially a transition to deeper rooted species such as tamarisk or mesquite. An estimated 502 acres has been mapped by Pima County as hydroriparian habitat along this reach (although reinterpreted for this analysis as xeroriparian with pockets of mesoriparian) and may be affected. The acreage that may be affected (502 acres) is less than that shown for Davidson Canyon Reach 2 in table 110 (570 acres), as some of the riparian areas along adjoining tributaries are unlikely to be affected by reductions in surface flow.

The major xeroriparian species present are adapted to cyclical climatic conditions and do not rely on groundwater. Effects on this xeroriparian habitat, from less water availability and reduced flood disturbance, could vary greatly, from reduced vegetation volume to mortality of individuals; however, a complete loss of xeroriparian habitat is unlikely.

Predicted Effect on Riparian Vegetation in Davidson Canyon (Reaches 3 and 4)

Predicted Hydrologic Changes

While historically some perennial or intermittent stream flow has occurred in Reach 4 of Davidson Canyon, as analyzed earlier in this section, the water sources in lower Davidson Canyon are unlikely to be connected with the regional aquifer or to experience changes owing to drawdown in that aquifer.

Changes in surface flow can be estimated to occur along these reaches and would range from 4.3 to 11.5 percent (SWCA Environmental Consultants 2012d); these changes theoretically could affect recharge to the shallow alluvial aquifer. However, these reaches are a great distance downstream, and as previously discussed, given the travel distance from Barrel Canyon, the recharge in lower Davidson Canyon is more likely to derive from closer tributaries, although certainly during larger flow events contribution from Barrel Canyon could occur. The effect on recharge is likely to be overestimated, with the contribution being less owing to the distance downstream of the project area and substantial channel losses. Predictions of losses to recharge to the shallow alluvial aquifer and therefore loss of water available to support riparian vegetation have a high level of uncertainty.

Expected Effects on Riparian Vegetation

Reach 3 of Davidson Canyon consists of xeroriparian habitat with pockets of mesoriparian habitat that may be supported by shallow alluvial groundwater. The major xeroriparian species present are adapted to cyclical climatic conditions and do not rely on groundwater. Effects on this xeroriparian habitat from less water availability and reduced flood disturbance are unlikely, given the expected reduction in flow.

Pockets of mesoriparian habitat are similarly unlikely to experience effects, given the unlikely effects on recharge of the alluvial aquifer.

Reach 4 of Davidson Canyon has been classified as hydroriparian habitat. Similarly, this habitat is unlikely to experience effects, given the unlikely effects on recharge of the alluvial aquifer.

Predicted Effect on Riparian Vegetation in Barrel Canyon (Reaches 1 and 2)

Predicted Hydrologic Changes

Drawdown in the regional aquifer is predicted to range from 10 to 100 feet in this location; however, this reach of Barrel Canyon is primarily xeroriparian, with pockets of mesoriparian vegetation. Some of this vegetation may rely on regional groundwater but is most likely relying on shallow alluvial groundwater, as there are no indications of perennial or intermittent flow in this reach and no extensive hydroriparian or mesoriparian galleries.

The primary hydrologic changes along Barrel Canyon would be the result of a reduction in surface runoff, which with high certainty would range from 17.2 to 45.8 percent. Even for the Barrel Alternative, for which stormwater management was redesigned to maximize downstream flow, this percentage only reflects the postclosure reduction in flow, and greater effects would be felt generally in the first 10 years of the mine life (up to a 30 to 40 percent reduction) before concurrent reclamation is established that allows more water to flow to the downstream watershed. The reduction in runoff would persist in the long term, even after final reclamation and closure, as some portions of the watershed would be permanently cut off.

Expected Effects on Riparian Vegetation

These reaches of Barrel Canyon are considered xeroriparian habitat with pockets of mesoriparian habitat. The primary concern is not the reduction in recharge of a shallow alluvial aquifer, as the major xeroriparian and mesoriparian species present are adapted to cyclical climatic conditions and do not rely on groundwater. Instead, the decrease in overall water availability in general would result in changes in riparian vegetation. These changes are difficult to quantify. Unlike hydroriparian species and the extensive studies on the San Pedro River and elsewhere, changes in xeroriparian vegetation as a result of water availability have not been greatly studied. In general, water availability does not necessarily change the species makeup of xeroriparian habitat but reduces the overall vitality, extensiveness, and health. These effects are quite easy to observe; overall water availability is the sole difference between the four classes of xeroriparian habitat defined and mapped by Pima County.

Effects on this xeroriparian habitat from less water availability and reduced flood disturbance could vary greatly, from reduced vegetation volume to mortality of individuals. A complete loss of xeroriparian habitat is unlikely, but a transition from high quality xeroriparian habitat to lesser quality xeroriparian habitat is highly likely in these reaches of Barrel Canyon. A total of 162 acres of riparian habitat has been mapped along these reaches that may be affected. The acreage that may be affected (162 acres) is less than that shown for Barrel Canyon Reaches 1 and 2 in table 110 (205 acres), as some of the riparian areas along adjoining tributaries are unlikely to be affected by reductions in surface flow.

Monitoring Intended to Assess Potential Stream Flow Impacts

In consideration of the uncertainty associated with predicting long-term impact to stream flow, three monitoring components have been incorporated into the "Mitigation and Monitoring Plan" (see appendix B for full details). The monitoring includes:

- **Monitoring to determine impacts from pit dewatering on downstream sites in Barrel and Davidson Canyons (FS-BR-22).** Monitoring would be conducted of surface water, alluvial groundwater, and deeper groundwater at sites in Barrel and Davidson Canyons. Several locations have already been installed and are being actively monitored, whereas others would require access from landowners.
- **Periodic validation and rerun of groundwater model throughout life of mine (FS-BR-27).** This measure would involve basic data collection of water levels, meteorological data, and water balance components, which would allow for the predictions of groundwater

impacts to be revised based on actual hydrologic observations. Specific wells to be monitored are listed in appendix B.

- **Continued operation and data gathering of USGS flow gage that would provide data for surface water flows downstream of the mine site (RC-SW-01).** Rosemont Copper would annually fund the USGS to operate and maintain the existing flow gage at Barrel Canyon.

Contextual Discussion of Effects on Empire Gulch and Cienega Creek

Empire Gulch

The potential impacts to Empire Gulch discussed above describe the changes to the natural environment, specifically changes that would occur in the type of vegetation and habitat in Empire Gulch, and the potential transition of the stream from perennial to ephemeral. Those impacts would also have more widespread effects on the human environment in Empire Gulch.

The historic Empire Ranch has been a working cattle ranch since the 1860s, and in 1976, it was listed in the National Register of Historic Places (NRHP). In the 1980s, public support developed to preserve the ranch and its natural resources in their pristine condition, which culminated in 1988 with a series of land exchanges that placed the property into public ownership under the administration of the BLM. Located in the heart of Empire Gulch and the Las Cienegas National Conservation Area, Empire Ranch is still a draw for the historic importance of the ranch itself and the natural beauty of the area. Ranching continues, as well as recreation activities, public events, and ongoing efforts to preserve and enhance the natural resources in this area. In 1997, the Empire Ranch Foundation was established as a private nonprofit organization to work with the BLM to develop private support to preserve the ranch buildings and enhance the educational and recreational opportunities it offers to the general public.

There is great uncertainty with the predictions regarding how much, where, and how fast groundwater drawdown might occur from dewatering associated with the mine pit. Based on the best available science as described in this resource section, impacts to Empire Gulch are more certain to occur than those to other perennial streams, and most scenarios indicate that effects would be seen within 50 years of closure of the mine. These effects would gradually increase over time, likely affecting flow at the springs in Empire Gulch, stream flow within the Empire Gulch channel, and the riparian gallery present along the channel. Due to the Forest Service's jurisdictional limitation that mitigation measures can be required only on NFS surface resources, no mitigation measures are proposed that would directly offset the impacts predicted to occur along Empire Gulch (see the "Mitigation and Monitoring" part of chapter 2, and appendix B for further detail).

These changes over time would not affect the historic nature of Empire Ranch, the ranch buildings, or likely even the continuing ranching operations. However, the eventual absence of free-flowing water, the loss of large trees, and the transition into a drier desert wash like that farther upstream would cause a substantial change to the character of Empire Ranch and the natural setting that is currently enjoyed at the ranch. This would represent a loss of some of the characteristics for which Empire Ranch was preserved and protected.

Cienega Creek

Cienega Creek extends from its headwaters near Sonoita approximately 36 miles downstream, flowing through both the Las Cienegas National Conservation Area and the Cienega Creek Natural Preserve. Throughout much of this length, Cienega Creek exhibits perennial or intermittent stream flow, and an extensive gallery of cottonwood and willow is supported along the Creek. In addition, the flood plain of Cienega Creek contains the remnants of once-extensive cienegas, or areas of shallow groundwater and wetland complexes.

Cienega Creek is noted for both scenic beauty and ecological significance. It forms an important connection for wildlife movement between sky islands in southern Arizona. It is one of the few remaining examples of a desert riparian community, exhibiting a high level of plant diversity in a relatively small geographic area. Pima County notes that the habitat along Cienega Creek supports more than 280 native species of mammals, birds, reptiles, amphibians, fish, and insects that either reside in or frequent the preserve and provides habitat for neotropical migratory birds, which seasonally use the area for nesting. The presence of perennial stream flow supports native frog and fish populations, including threatened and endangered species.

The ecological, recreation, and cultural importance of Cienega Creek is tied irrevocably to its hydrology. Cienega Creek is valuable because it is a perennial riparian corridor. Predictions of impact to Cienega Creek are less certain than those for Empire Gulch and encompass a wide range of possibilities, from no impact at all, to extensive dewatering and drying. The timing is also uncertain, with possible changes occurring many decades or hundreds of years in the future. Changes in the hydrology severe enough to cause dewatering of Cienega Creek are one possible outcome of the mine, and the likelihood of mine effects becoming severe enough to dewater Cienega Creek also increases with climate change and increased groundwater demand within the basin. If these severe effects were to occur, much of the value of Cienega Creek for recreation, wildlife habitat, scenic beauty, and cultural importance would be lost.

Effect on Outstanding Arizona Waters

Seven criteria were developed by the Coronado for the purposes of the FEIS and are assessed to analyze potential impacts to Outstanding Arizona Waters: changes in perennial stream flow; change in groundwater quality; change in surface water quality and ability to meet wadeable, perennial standards; change in riparian vegetation; change in geomorphology; and change in subflow. These are summarized in table 111 for the Outstanding Arizona Water reaches of lower Davidson Canyon and lower Cienega Creek and in table 113 for the Outstanding Arizona Water reaches of Upper Cienega Creek. This analysis reflects the criteria developed and analyzed by the Coronado, which will differ from those used by the State of Arizona to make their determination of the ability of the proposed project to meet regulatory requirements.

Davidson Canyon and Lower Cienega Creek

Potential impacts to each of the seven assessment criteria for Outstanding Arizona Waters are summarized in table 111 for Davidson Canyon and Lower Cienega Creek (below the confluence with Davidson Canyon). Each assessment criterion is also further described below.

Ability to Meet Antidegradation Standards

Predicted water quality for stormwater runoff in Barrel Canyon is discussed in the "Surface Water Quality" resource section, as are all known existing water quality data for Davidson Canyon, Lower Cienega Creek, and Barrel Canyon.

Table 111. Potential to affect Outstanding Arizona Water in Davidson Canyon and Lower Cienega Creek

Criteria	EIS Resource Section that Contains Analysis	Summary of Impacts
Perennial Stream Flow	Seeps, Springs, and Riparian Areas	Possible 4.3 to 11.5% reduction in recharge of alluvial aquifer from surface flow; impacts muted by distance flow has to travel from site to downstream; prediction has high level of uncertainty. Perennial flow in lower Davidson Canyon is not occurring at present and has not occurred for several years; unlikely to be affected by changes in recharge; no impacts predicted.
Groundwater Quality	Groundwater Quality and Geochemistry	Seepage does not exceed any aquifer water quality standards; no impacts predicted.
Surface Water Quality	Surface Water Quality and Seeps, Springs, and Riparian Areas	Predicted runoff water quality from waste rock and soil cover meets surface water quality standards in Barrel Canyon, or standards are already exceeded. Full analysis of antidegradation standards and compliance with surface water standards in the Outstanding Arizona Water reaches of Davidson Canyon and Cienega Creek is under the jurisdiction of ADEQ and has not yet been conducted. However, screening analysis developed by the Coronado suggests that molybdenum and sulfate may be elevated in mine stormwater runoff but are likely to be reduced in part by several mitigations, including waste rock segregation requirements (discussed in detail below, see table 112).
Riparian Vegetation	Seeps, Springs, and Riparian Areas	Based on the expected changes in runoff (from 4.3 to 11.5% reduction), no changes in riparian vegetation expected.
Geomorphology	Surface Water Quality	Sediment loads in system would change, but geomorphology of stream channel is unlikely to change; scour/aggradation changes to Outstanding Arizona Water highly unlikely.
Subflow (for Lower Cienega Creek)	Groundwater Quantity	Contribution of Davidson Canyon subflow to Cienega Creek estimated at 8 to 24%; possible 4.3 to 11.5% reduction in recharge of Davidson Canyon alluvial aquifer from surface flow; impacts muted by distance flow has to travel from site to downstream; therefore, prediction has high level of uncertainty. Cumulatively, possible reduction in flow in Lower Cienega Creek owing to reduction in subflow from Davidson Canyon is minimal.
Ability to Meet Anti-Degradation Standards and Wadeable, Perennial Standards	Seeps, Springs, and Riparian Areas; Surface Water Quality	Discussed in detail below.

Direct comparison of predicted water quality from waste rock runoff (see "Surface Water Quality" resource section) to the existing water quality in Davidson Canyon and Lower Cienega Creek is problematic and not appropriate, given that the Outstanding Arizona Water portion of Davidson Canyon is more than 12 miles downstream in the watershed and the contribution from the mine site would represent only a portion of the runoff reaching the Outstanding Arizona Water. More importantly, there are no known stormwater samples available for either Davidson Canyon or Lower

Cienega Creek. All known water quality samples, including those contained in the “Surface Water Quality” resource section, are for base flow, not storm flow.

Because there are no known stormwater samples from anywhere within the Davidson Canyon watershed, except those collected by Rosemont Copper in Barrel Canyon, it is impossible to conduct a full analysis of whether the mine would degrade water quality in the Outstanding Arizona Water segments of Davidson Canyon and Lower Cienega Creek. Not only does this prevent comparison of predicted stormwater quality with existing stormwater quality in these Outstanding Arizona Water reaches, but because Arizona surface water standards change based on water hardness, it also prevents even a comparison of predicted stormwater quality with surface water quality standards in the Outstanding Arizona Water reaches. Furthermore, based on discussions with ADEQ on preliminary drafts of the FEIS, it was made clear to the Coronado that the responsibility and jurisdiction for assessing whether the mine meets antidegradation criteria lie with ADEQ. The person seeking authorization for a regulated discharge to a tributary to, or upstream of, an Outstanding Arizona Water (in this case Rosemont Copper) has the responsibility to demonstrate to the State of Arizona that the regulated discharge will not degrade existing water quality in the downstream Outstanding Arizona Water. This demonstration by Rosemont Copper, and determination by the State of Arizona, has not yet been completed. Independent of this determination, the potential for degradation of Outstanding Arizona Waters was raised by the public as an issue of importance and therefore the Forest Service has the responsibility under NEPA to take a “hard look” at the potential for degradation. The Coronado determined that a screening-level analysis could be conducted with available data to identify potential constituents that could be elevated by the runoff from the waste rock facility.

Results from the screening analysis are summarized in table 112 and described more fully in the record (SWCA Environmental Consultants 2013k). Two scenarios are assessed, corresponding to the two scenarios assessed in the “Surface Water Quality” resource section: runoff from waste rock, and runoff from soil cover. Based on the screening analysis, concentrations of most constituents actually are predicted to decrease under postmine conditions. Concentrations of several other constituents are suggested to increase, including total and dissolved fluoride, dissolved aluminum, dissolved selenium, and dissolved sodium. These increases are less than 10 percent and may not be considered significant, given the relatively great uncertainty associated with this analysis. The screening analysis for runoff from waste rock indicates that two constituents may be elevated in mine runoff at levels that suggest they could present antidegradation problems: total and dissolved molybdenum, and total and dissolved sulfate. The screening analysis for runoff from soil cover suggests that molybdenum and sulfate would not be elevated but that dissolved arsenic, dissolved iron, and dissolved sodium could present antidegradation problems. In addition, dissolved and total mercury is substantially higher. Most waste rock samples contained mercury concentrations below detection limits (74 out of 78 samples collected), but these detection limits are higher than surface water standards and therefore are not able to be incorporated into this part of the analysis. Many or even all of these unusable samples could have very low mercury concentrations. The usable samples include one sample with a very high concentration of mercury (0.03 mg/L). Because of the small number of usable samples, this single sample has a large influence on the predictions. However, it appears to be a legitimate sample, and it still indicates a potential for degradation from stormwater interacting with soil cover.
The actual runoff water quality would be predicted to be a mix of the waste rock and soil cover estimates.

Table 112. Summary of screening analysis to identify potential problem constituents in mine runoff

	Average of Existing Water Quality in Barrel Canyon and Tributaries (mg/L)	Predicted Runoff Water Quality from Waste Rock (mg/L)	Predicted Runoff Water Quality from Soil Cover (mg/L)	Premine Prediction of Watershed Water Quality (mg/L)*	Postmine Prediction of Watershed Water Quality using Waste Rock Runoff (mg/L)†	Percent Difference between Pre- and Postmine Watershed Water Quality‡	Postmine Prediction of Watershed Water Quality using Soil Cover Runoff (mg/L)†	Percent Difference between Pre- and Postmine Watershed Water Quality†
Aluminum (dissolved)	0.4248	0.2050	0.4870	0.4248	0.3918	−8%	0.4341	2%
Aluminum (total)	87.14	0.2050	0.4870	87.14	74.10	−15%	74.14	−15%
Antimony (dissolved)	0.0240	0.0100	0.0052	0.0240	0.0219	−9%	0.0212	−12%
Antimony (total)	0.0436	0.0100	0.0052	0.0436	0.0386	−12%	0.0379	−13%
Arsenic (dissolved)	0.0161	0.0130	0.0335	0.0161	0.0157	−3%	**0.0187**	**16%**
Arsenic (total)	0.1123	0.0130	0.0335	0.1123	0.0974	−13%	0.1005	−11%
Barium (dissolved)	0.0783	0.0071	0.0047	0.0783	0.0676	−14%	0.0672	−14%
Barium (total)	1.1623	0.0071	0.0047	1.1623	0.9890	−15%	0.9886	−15%
Beryllium (dissolved)	0.0084	0.0010	0.0010	0.0084	0.0072	−13%	0.0072	−13%
Beryllium (total)	0.0123	0.0010	0.0010	0.0123	0.0106	−14%	0.0106	−14%
Cadmium (dissolved)	0.0058	0.0010	0.0010	0.0058	0.0051	−12%	0.0051	−12%
Cadmium (total)	0.0238	0.0010	0.0010	0.0238	0.0204	−14%	0.0204	−14%
Calcium (dissolved)	25.24	16.42	6.6	25.24	23.92	−5%	22.44	−11%
Calcium (total)	214.9	16.42	6.6	214.9	185.1	−14%	183.7	−15%
Chloride (dissolved)	2.804	0.9630	0.5357	2.804	2.528	−10%	2.463	−12%
Chloride (total)	5.679	0.9630	0.5357	5.679	4.972	−12%	4.907	−14%
Chromium (dissolved)	0.0136	0.0030	0.0030	0.0136	0.0120	−12%	0.0120	−12%
Chromium (total)	0.1105	0.0030	0.0030	0.1105	0.0944	−15%	0.0944	−15%
Copper (dissolved)	0.0331	0.0085	0.0067	0.0331	0.0294	−11%	0.0291	−12%

	Average of Existing Water Quality in Barrel Canyon and Tributaries (mg/L)	Predicted Runoff Water Quality from Waste Rock (mg/L)	Predicted Runoff Water Quality from Soil Cover (mg/L)	Premine Prediction of Watershed Water Quality (mg/L)*	Postmine Prediction of Watershed Water Quality using Waste Rock Runoff (mg/L)[†]	Percent Difference between Pre- and Postmine Watershed Water Quality[‡]	Postmine Prediction of Watershed Water Quality using Soil Cover Runoff (mg/L)[†]	Percent Difference between Pre- and Postmine Watershed Water Quality[†]
Copper (total)	2.947	0.0085	0.0067	2.947	2.507	−15%	2.506	−15%
Fluoride (dissolved)	0.2500	0.3316	0.2063	0.2500	0.2622	5%	0.2434	−3%
Fluoride (total)	0.2163	0.3316	0.2063	0.2163	0.2336	8%	0.2148	−1%
Iron (dissolved)	0.1418	0.1638	0.2433	0.1418	0.1451	2%	**0.1570**	**11%**
Iron (total)	102.7	0.1638	0.2433	102.7	87.3	−15%	87.33	−15%
Lead (dissolved)	0.0235	0.0048	0.0151	0.0235	0.0207	−12%	0.0222	−5%
Lead (total)	0.8837	0.0048	0.0151	0.8837	0.7519	−15%	0.7534	−15%
Magnesium (dissolved)	1.990	1.064	0.8167	1.990	1.851	−7%	1.814	−9%
Magnesium (total)	47.89	1.064	0.8167	47.89	40.86	−15%	40.83	−15%
Manganese (dissolved)	0.3406	0.0069	0.1610	0.3406	0.2905	−15%	0.3136	−8%
Manganese (total)	6.131	0.0069	0.1610	6.131	5.212	−15%	5.235	−15%
Mercury (dissolved)	0.0001	0.0002	0.0101	0.0001	0.0002	9%	**0.0016**	**1050%**
Mercury (total)	0.0007	0.0002	0.0101	0.0007	0.0006	−10%	**0.0021**	**201%**
Molybdenum (dissolved)	0.0172	0.0405	0.0117	0.0172	**0.0207**	**20%**	0.0164	−5%
Molybdenum (total)	0.0178	0.0405	0.0117	0.0178	**0.0212**	**19%**	0.0169	−5%
Nickel (dissolved)	0.2966	0.0050	0.0050	0.2966	0.2529	−15%	0.2529	−15%
Nickel (total)	0.6783	0.0050	0.0050	0.6783	0.5773	−15%	0.5772	−15%
Nitrate + Nitrite (total, as N)	1.704	0.031	Not sampled	1.704	1.453	−15%	Not sampled	Not sampled
Potassium (dissolved)	4.795	2.934	1.503	4.795	4.515	−6%	4.301	−10%
Potassium (total)	28.46	2.934	1.503	28.46	24.63	−13%	24.42	−14%

	Average of Existing Water Quality in Barrel Canyon and Tributaries (mg/L)	Predicted Runoff Water Quality from Waste Rock (mg/L)	Predicted Runoff Water Quality from Soil Cover (mg/L)	Premine Prediction of Watershed Water Quality (mg/L)*	Postmine Prediction of Watershed Water Quality using Waste Rock Runoff (mg/L)†	Percent Difference between Pre- and Postmine Watershed Water Quality‡	Postmine Prediction of Watershed Water Quality using Soil Cover Runoff (mg/L)†	Percent Difference between Pre- and Postmine Watershed Water Quality†
Selenium (dissolved)	0.0140	0.0200	0.0200	0.0140	0.0149	6%	0.0149	6%
Selenium (total)	0.9864	0.0200	0.0200	0.9864	0.8414	−15%	0.8414	−15%
Silver (dissolved)	0.0090	0.0025	0.0025	0.0090	0.0080	−11%	0.0080	−11%
Silver (total)	2.714	0.0025	0.0025	2.714	2.307	−15%	2.307	−15%
Sodium (dissolved)	2.518	4.167	6.1	2.518	2.765	10%	**3.055**	**21%**
Sodium (total)	7.008	4.167	6.1	7.008	6.582	−6%	6.872	−2%
Sulfate (dissolved)	4.475	33.126	1.98	4.475	**8.773**	**96%**	4.101	−8%
Sulfate (total)	7.793	33.126	1.98	7.793	**11.593**	**49%**	6.921	−11%
Thallium (dissolved)	0.0136	0.0082	0.0028	0.0136	0.0128	−6%	0.0120	−12%
Thallium (total)	0.0328	0.0082	0.0028	0.0328	0.0291	−11%	0.0283	−14%
Total Dissolved Solids	194.68	78.41	Not sampled	194.68	177.24	−9%	Not sampled	Not sampled
Zinc (dissolved)	0.0697	0.0058	0.0066	0.0697	0.0601	−14%	0.0602	−14%
Zinc (total)	2.202	0.0058	0.0066	2.202	1.873	−15%	1.873	−15%

Notes:

Bold numbers indicate that the screening analysis suggests a significant increase in postmine concentrations (greater than a 10 percent change).

* No stormwater quality samples have been identified anywhere within the Davidson Canyon watershed, except for those samples collected by Rosemont Copper in Barrel Canyon and its tributaries. Therefore, the premine watershed water quality can only be estimated by using these water quality samples.

† Postmine water quality is estimated by using a weighted average, with 15% contribution from the predicted runoff from the waste rock or soil cover, and 85% contribution from the existing water quality in Barrel Canyon, which is assumed to be representative of the watershed as a whole for lack of other stormwater samples.

‡ Negative numbers indicate water quality is improved from existing conditions; positive numbers indicate water quality is degraded from existing conditions.

As noted in the "Surface Water Quality" resource section, there are several mitigations that suggest this is a conservative estimate. These include the requirement for operational testing and segregation of waste rock that may have the potential for acid generation or that may be problematic with respect to water quality, along with the placement of a cover of growth media over much of the waste rock facility. The screening analysis presented assumes that all stormwater runoff has the opportunity to interact with waste rock and that no waste rock has been segregated.

The Forest Service does not have the responsibility or jurisdiction to determine whether or not the mine would degrade water quality or violate water quality standards in the Outstanding Arizona Water reaches; this determination responsibility lies with ADEQ. However, the Forest Service does have the responsibility to assess and disclose potential resource impacts; the purpose of the screening analysis is intended to assess the potential to impact water quality beyond Barrel Canyon.

The "Groundwater Quality and Geochemistry" resource section also analyzes the potential for tailings seepage to daylight in Barrel Canyon. As noted in that section, the amount of seepage is equivalent to about 13 acre-feet per year, which is less than 1 percent of the average annual runoff. As a total of the entire watershed being analyzed under the screening analysis, the volume of tailings seepage is incredibly small, about 1 part in 1,000. The same screening analysis was conducted that incorporated tailings seepage into storm flows, but the results did not change from the scenarios already considered and shown in table 112.

Ability to Meet Wadeable, Perennial Stream Standards

Lower Cienega Creek currently meets the regulatory definition of a wadeable, perennial stream. As such, regulatory requirements specific to biological integrity (taxa richness, species composition, tolerance, and functional organization comparable to that of a stream with reference conditions in Arizona) and bottom deposits would need to be met. With the exception of water quality described above, changes predicted in Lower Davidson Canyon and Lower Cienega Creek are limited to 4.3 to 11.5 percent reduction in ephemeral storm flow. Biological communities in Lower Cienega Creek would be sensitive to changes in base flow but are unlikely to be affected by changes in ephemeral storm flow. It was also concluded that this level of change in stormwater availability is unlikely to substantially change the amount of subflow from Davidson Canyon to Cienega Creek. Based on the analyses conducted, no expected effects from the proposed mine would have the potential to change biological integrity along any portion of Lower Cienega Creek. Analysis of geomorphological changes indicates that changes in sedimentation, aggradation, or scour are unlikely to occur due to the hydrologic changes imposed by the mine and therefore are unlikely to affect either biological integrity or surface deposits. The water quality screening analysis suggests that some constituents may be elevated in mine runoff, but because of the lack of stormwater samples in Lower Davidson Canyon or Lower Cienega Creek, this screening analysis is unable to predict water quality changes in these Outstanding Arizona Water reaches.

Summary of Expected Effects on Outstanding Arizona Waters

The analysis of effects on Outstanding Arizona Waters is based on criteria developed solely by the Coronado that were designed to include both regulatory requirements as well as the original reasons for nominating these areas as Outstanding Arizona Waters. The State of Arizona has yet to make a determination on whether regulatory standards would be met.

In summary, the only potential effect on the Outstanding Arizona Waters in Lower Davidson Canyon and Lower Cienega Creek would be the result of a decrease in runoff that would occur because portions of the Davidson Canyon watershed would be cut off in perpetuity by the mine site. This reduction in ephemeral flow is estimated to be 4.3 to 11.5 percent in lower Davidson Canyon. The reduction in surface flow itself would likely have no impact to riparian vegetation or water quality; it could represent a reduction in recharge to the shallow alluvial aquifer and subflow from Davidson Canyon to Cienega Creek. The distance downstream of the project area (12 miles) that flows have to travel before reaching lower Davidson Canyon gives the predicted effect a high level of uncertainty, as recharge in lower Davidson Canyon is more likely to occur either from very large storm events or from more localized runoff events. A screening analysis suggests that several constituents may be elevated due to runoff from the waste rock, although this possibility is reduced by several safety factors built into operation of the mine (see table 112).

Upper Cienega Creek

Potential impacts to each of the six assessment criteria for Outstanding Arizona Waters are summarized in table 113 for Upper Cienega Creek. Each assessment criterion is also further described below.

Table 113. Potential to affect Outstanding Arizona Water in Upper Cienega Creek

Criteria	EIS Resource Section that Contains Analysis	Summary of Impacts
Perennial Stream Flow	Seeps, Springs, and Riparian Areas	Results are mixed. Up to 150 years after closure, most estimates indicate no change in perennial nature of stream, with some possibility of shifting to intermittent. Up to 1,000 years after closure, several estimates indicate no change in perennial nature of stream, and several estimates indicate a shift to intermittent flow or conversion to an ephemeral stream.
Groundwater Quality	Groundwater Quality and Geochemistry	Seepage does not exceed any aquifer water quality standards; no impacts predicted.
Surface Water Quality	Surface Water Quality	No change in surface runoff to Upper Cienega Creek. In the near term, up to 50 years after closure, no increased risk of degraded water quality caused by extremely low-flow conditions. Up to 150 years after closure, results are mixed. Most estimates indicate some increased risk of low-flow conditions increasing, anywhere from seasonally during the summer to nearly the entire year.
Riparian Vegetation	Seeps, Springs, and Riparian Areas	Most estimates indicate that there is unlikely to be any change in riparian vegetation, even up to 1,000 years after closure. The highest estimates of groundwater drawdown indicate that while there may not be widespread changes from hydroriparian to xeroriparian vegetation, there is likely to be a contraction of the hydroriparian area, with conversion occurring at the transitional margins.
Geomorphology	Surface Water Quality	No change in surface runoff to Upper Cienega Creek.
Ability to Meet Wadeable, Perennial Standards	Seeps, Springs, and Riparian Areas; Surface Water Quality	Discussed in detail below.

Ability to Meet Wadeable, Perennial Stream Standards

Upper Cienega Creek currently meets the regulatory definition of a wadeable, perennial stream. As such, regulatory requirements specific to biological integrity (taxa richness, species composition, tolerance, and functional organization comparable to that of a stream with reference conditions in Arizona) and bottom deposits would need to be met. The potential for reductions in stream flow would potentially drive water quality changes as well, as discussed earlier in this section. Results of the models are mixed. By 50 years after closure, only one modeling scenario out of five suggests that there would be an increase in the risk of low-flow conditions occurring. By 150 years after closure, four out of five modeling scenarios suggest that there would be an increase in the risk of low-flow conditions occurring. By 1,000 years after closure, all modeling scenarios agree that there would some level of increase in the risk of low-flow conditions.

These low-flow conditions would increase water temperature, increase nutrient loads, and decrease the assimilative capacity of the stream. Changes in these characteristics would have an effect on the aquatic biota and the characteristics of biological integrity listed above.

Summary of Expected Effects on Outstanding Arizona Waters

The analysis of effects on Outstanding Arizona Waters is based on criteria developed solely by the Coronado that were designed to include both regulatory requirements as well as the original reasons for nominating these areas as Outstanding Arizona Waters. The State of Arizona has yet to make a determination on whether regulatory standards would be met.

Predictions with the most certainty are during the near term, up to 50 years after closure of the mine, during which there are few predicted effects on the Outstanding Arizona Water along Upper Cienega Creek from the headwaters to the confluence with Davidson Canyon. Over the long term (up to 1,000 years after closure), the risk increases, although predictions are mixed. Some modeling scenarios suggest that there would be no or little change in flow conditions, and some modeling scenarios suggest that the stream could shift from perennial flow to intermittent flow, or even completely transition to ephemeral flow. At the same time, the frequency of low-flow conditions that could degrade water quality would increase. Changes in either the nature of flow or the frequency of low-flow conditions could affect this Outstanding Arizona Water. Predictions of these conditions occurring are highly uncertain due to limitations in the accuracy of the models and the long time frames involved.

Monitoring Intended to Assess Potential Impacts to Outstanding Arizona Waters

In addition to the three monitoring requirements described previously associated with stream flow impacts, two other monitoring measures have been incorporated into the "Mitigation and Monitoring Plan" to address uncertainty associated with impacts to Outstanding Arizona Waters (see appendix B for full details). The additional monitoring includes:

- **Sediment transport monitoring (FS-SR-05).** The movement of sediment between the mine facility and SR 83 would be monitored to identify areas of scour or aggradation that could be caused by changes in sediment load and surface flow.
- **Detention and testing of stormwater (OA-SW-01).** This mitigation measure requires detention and testing of stormwater quality from perimeter waste rock buttress areas for water quality testing prior to flowing downstream of the mine site. This would also allow for a reduction in suspended sediment in stormwater flows before flowing downstream.

Proposed Action

Effect on Seeps and Springs

The estimated impacts to seeps and springs, along with the rationale for this assessment, are presented in table 114. Direct impacts refer to springs that are within the footprint of an action alternative and would be disturbed, covered, or otherwise removed and would no longer function as a natural spring. Indirect impacts refer to springs that would not be physically disturbed but that may experience changes in hydrology as a result of groundwater level declines. Refer to the "Methodology" part of this resource section for more information on how spring impacts were estimated.

Table 114. Estimated impacts to springs and seeps as a result of proposed action

ID	Spring	Type of Impact	Rationale	Riparian Impacts
1	Barrel Spring	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
2	Basin Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Deergrass, willows, false indigo present upstream of spring; unlikely to be affected
3	Batamout Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Netleaf hackberry, soapberry present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
4	Bee Spring	Direct	Inside footprint of disturbance	Oaks present; xeroriparian/ mesoriparian habitat would be lost
5	Big Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Soapberry present; xeroriparian/ mesoriparian habitat may be lost or experience reduced vitality
6	Bobo Spring	Unlikely	Outside bounds of analysis; beyond 5-foot groundwater drawdown contour	None
7	Bootlegger Spring	Unlikely	Outside bounds of analysis; beyond 5-foot groundwater drawdown contour	None
8	Bowman Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
9	Box Canyon Spring – Stock Drinker No. 1	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Ash, oak, netleaf hackberry, grapevine, poison ivy, evergreen sumac, Goodding's willow, mesquite, juniper present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
10	Box Canyon Spring – Stock Drinker No. 2	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Ash, oak, netleaf hackberry, grapevine, poison ivy, evergreen sumac, Goodding's willow, mesquite, juniper present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
11	California Mine Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
12	Chavez Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Giant sedge, walnut, ash, grapevine, maidenhair fern present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality

ID	Spring	Type of Impact	Rationale	Riparian Impacts
13	Cold Water Spring	Unlikely	Outside bounds of analysis; beyond 5-foot groundwater drawdown contour	None
14	Cow Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
15	Crucero Spring No. 1	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Oaks, junipers, hackberry, indigo, deergrass, willows present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
16	Crucero Spring No. 2	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
17	Dam Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
18	Davidson Spring	Unlikely	Source of flow is likely from Empire Mountains and disconnected from Davidson Canyon (Tetra Tech 2010a)	None
19	Deering Spring	Highly likely; Indirect	Inside 5-foot groundwater drawdown contour; flow observations indicate consistent water presence and suggest a regional source of water	Giant sedge, deergrass, oak, juniper, fig present; xeroriparian/mesoriparian habitat would be lost or would experience reduced vitality
20	Diesler Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Oak, cottonwood, willow present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
21	Escondido Spring	Unlikely	See Outstanding Arizona Water section for analysis	None
22	Feliz Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Oaks present; xeroriparian/ mesoriparian habitat may be lost
23	Fence Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
24	Fig Tree Spring	Highly likely; Indirect	Inside 5-foot groundwater drawdown contour; flow observations indicate consistent water presence and suggest a regional source of water	Giant sedge, oak, fig, milkweed present; xeroriparian/mesoriparian habitat would be lost or would experience reduced vitality
25	Heiter Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Netleaf hackberry present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
26	Helvetia Spring	Highly likely; Indirect	Inside 5-foot groundwater drawdown contour; flow observations indicate consistent water presence and suggest a regional source of water	Ash, willow, buckthorn, evergreen sumac, grapevine, giant sedge present; hydroriparian/mesoriparian habitat would be lost or would experience reduced vitality
27	Hilton Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Unknown
28	Horse Pasture Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Mesquite, netleaf hackberry, juniper, walnut, grapevine present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
29	HQ Water Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Cottonwood, willow present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
30	Indian Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None

ID	Spring	Type of Impact	Rationale	Riparian Impacts
31	La Cholla Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Oak, willow, hackberry present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
32	Little Indian Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
33	Locust Spring	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
34	Lower Mulberry Spring	Highly likely; Indirect	Inside 5-foot groundwater drawdown contour; flow observations indicate consistent water presence and suggest a regional source of water	Juniper, soapberry, hackberry, seep willow present; xeroriparian/ mesoriparian habitat would be lost or would experience reduced vitality
35	McCleary Dam	Direct	Inside footprint of disturbance	Oak, juniper present; xeroriparian/ mesoriparian habitat would be lost
36	McCleary No. 1	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
37	McCleary No. 2	Highly likely; Indirect	Inside 5-foot groundwater drawdown contour; flow observations indicate consistent water presence and suggest a regional source of water	Oak, sumac present; xeroriparian/ mesoriparian habitat would be lost
38	Mescal Spring	Unlikely	Outside bounds of analysis; beyond 5-foot groundwater drawdown contour	None
39	Mesquite Flat Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Hackberry, soapberry, seep willow, grapevine present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
40	Mine Water Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
41	Mudhole Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Giant sedge, Goodding’s willow, deergrass present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
42	Mueller Spring	Direct	Inside footprint of disturbance	None
43	Mulberry Canyon	Highly likely; Indirect	Inside 5-foot groundwater drawdown contour; flow observations indicate consistent water presence and suggest a regional source of water	Juniper, seep willow, rabbitsfoot grass, giant sedge present; xeroriparian/ mesoriparian habitat would be lost or would experience reduced vitality
44	Mulberry Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Juniper, hackberry present; xeroriparian/mesoriparian habitat may be lost or experience reduced vitality
45	Oak Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	False indigo bush, deergrass present; xeroriparian habitat may be lost or experience reduced vitality
46	Ojo Blanco Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Willow, deergrass, poison ivy present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
47	Ophir Gulch Well	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Madrean evergreen woodland present; xeroriparian/mesoriparian habitat may be lost or experience reduced vitality
48	Paja Verde Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None

ID	Spring	Type of Impact	Rationale	Riparian Impacts
49	Papago Spring (No. 2)	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
50	Peligro Adit	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
51	Proctor Box Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Ash, oak, netleaf hackberry, grapevine, poison ivy, evergreen sumac, Goodding's willow, mesquite, juniper, wait-a-minute bush present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
52	Questa Spring	Highly likely; Indirect	Inside 5-foot groundwater drawdown contour; flow observations indicate consistent water presence and suggest a regional source of water	None
53	Rock Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Deergrass present; xeroriparian/ mesoriparian habitat may be lost or experience reduced vitality
54	Rockhouse Spring	Unlikely	Outside bounds of analysis; beyond 5-foot groundwater drawdown contour	None
55	Rosemont Spring	Direct	Inside footprint of disturbance	Willow, juniper, false indigo, deergrass present; hydroriparian/mesoriparian habitat would be lost
56	Ruelas Spring	Highly likely; Indirect	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source; however, proximity to pit likely to affect local flow	Willow, hackberry present; hydroriparian/mesoriparian habitat would be lost or would experience reduced vitality
57	Ruelas Spring Number Two and Three	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
58	Rust Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
59	Sanford Spring	Unlikely	Outside bounds of analysis; beyond 5-foot groundwater drawdown contour	None
60	Scholefield No. 1 Spring	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
61	Scholefield No. 2 Spring	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
62	Scholefield No. 3 Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
63	Shamrod Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Hackberry, sumac, buckthorn, grapevine present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
64	Siphon Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None

ID	Spring	Type of Impact	Rationale	Riparian Impacts
65	Soldier Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
66	SS-2 (Casita Spring)	Unlikely	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source	None
67	SW	Highly likely; Indirect	Flow observations indicate large periods with no flow and suggest a likely local, ephemeral source; however, proximity to pit likely to affect local flow	Oak, pinyon pine, false indigo, silktassel, juniper; xeroriparian/ mesoriparian habitat would be lost or would experience reduced vitality
68	Sycamore Spring	Highly likely; Indirect	Inside 5-foot groundwater drawdown contour; flow observations indicate consistent water presence and suggest a regional source of water	Sycamore, ash, walnut, hackberry, cottonwood, willow, giant sedge; hydroriparian/mesoriparian habitat would be lost or would experience reduced vitality
69	Tree Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Cottonwood, soapberry, deergrass present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
70	Tub Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Hackberry, oak present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
71	Tunnel Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
72	Tunnel Spring # 2	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
73	Unnamed Spring (South of Deering Spring)	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Willow, juniper, silk tassel, smooth sumac, locust, deergrass present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
74	Unnamed Spring (in Box Canyon)	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Willow present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
75	Unnamed Spring (Reach 2)	Unlikely	See “Outstanding Arizona Waters” part of this resource section for analysis	None
76	Unnamed Spring (in South Sycamore Canyon)	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Sycamore, ash, willow, cottonwood, deergrass, horsetail, false indigo, poison ivy present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
77	Unnamed Spring No. 1	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
78	Unnamed Spring No. 12	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
79	Unnamed Spring No. 13	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
80	Unnamed Spring No. 14	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Mesquite present; xeroriparian/ mesoriparian habitat may be lost or experience reduced vitality
81	Unnamed Spring No. 16	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None

ID	Spring	Type of Impact	Rationale	Riparian Impacts
82	Unnamed Spring No. 17	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Ash, deergrass present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
83	Unnamed Spring No. 18	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Ash, walnut present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
84	Unnamed Spring No. 2	Direct	Inside footprint of disturbance	None
85	Unnamed Spring No. 20	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	None
86	Unnamed Spring No. 21	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Mesquite, soapberry, hackberry, catclaw, desert cotton present; xeroriparian/mesoriparian habitat may be lost or experience reduced vitality
87	Unnamed Spring No. 22	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Deergrass present; xeroriparian/ mesoriparian habitat may be lost or experience reduced vitality
88	Unnamed Spring No. 24	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Cottonwood, soapberry present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
89	Unnamed Spring No. 3	Direct	Inside footprint of disturbance	None
90	Unnamed Spring No. 4	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Ash present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
91	Unnamed Spring No. 5	Direct	Inside footprint of disturbance	Deergrass present; xeroriparian/ mesoriparian habitat would be lost or experience reduced vitality
92	Unnamed Spring No. 7	Unlikely	Outside bounds of analysis; beyond 5-foot groundwater drawdown contour	None
93	Upper Empire Gulch Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Cottonwood, willow present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality
94	Water Develop Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Oak, netleaf hackberry, locust, grapevine present; hydroriparian/ mesoriparian habitat may be lost or experience reduced vitality
95	Zackendorf Spring	Possible; Indirect	Inside 5-foot groundwater drawdown contour; source of water unknown	Cottonwood, willow, evergreen sumac, oak, mountain mahogany, cattails, giant sedge, maidenhair fern present; hydroriparian/mesoriparian habitat may be lost or experience reduced vitality

Notes:

High: The predicted changes in hydrology owing to the mine would impact resource function, and the source of water can either be estimated with high certainty to be in connection with the regional aquifer or impacts would occur no matter what the source of water.

Possible: Reduction in flow could occur as a result of predicted changes in hydrology owing to the mine, but uncertainty exists regarding the source of the water.

Unlikely: Predicted changes in hydrology owing to the mine are small enough that they are unlikely to cause a reduction in flow, regardless of the source of water, or the source of the water is local and unlikely to be affected by drawdown associated with the pit.

Of the 95 seeps or springs listed in table 114, 17 are expected to be impacted with high certainty, either directly by surface disturbance (7 of the 17 springs) or indirectly by reduction in flow severe enough to impact their function as a resource owing to predicted drawdown in the regional aquifer or their proximity to the pit (10 of the 17 springs). An additional 59 springs possibly could be impacted by reductions in groundwater levels; these springs lie within the area predicted to see at least 5 feet in groundwater drawdown but have an indeterminate source of water. Another 19 springs are unlikely to be impacted, either because field observations indicate they are fed by local and ephemeral sources or because of their distance from the mine pit.

Local areas of riparian habitat are associated with 49 of the springs that would or possibly would be indirectly impacted by the loss of water from these springs, based on field observations of species types present at these springs. These local riparian zones include the following: 10 areas of xeroriparian/mesoriparian habitat that would be impacted with high certainty; eight areas of xeroriparian/mesoriparian habitat that may be impacted with low certainty; four areas of hydroriparian/mesoriparian habitat that would be impacted with high certainty; and 27 areas of hydroriparian/mesoriparian habitat that may be impacted with low certainty.

The proposed action would also directly disturb 686 acres of xeroriparian habitat associated with onsite washes. These are the riparian areas mapped by Pima County that fall within the security fence or other areas of ground disturbance.

Any intermittent stream segments in Sycamore Canyon (north of the mine site) not accounted for as individual springs would experience similar impacts as those described for Sycamore Spring (ID No. 68) and Unnamed Spring No. 18 (ID No. 83).

Any intermittent stream segments in Sycamore Canyon (a different canyon south of the mine site) not accounted for as individual springs would experience similar impacts as those described for SW (ID No. 67) and Unnamed Spring in South Sycamore Canyon (ID No. 76).

Any intermittent stream segments in Mulberry Canyon not accounted for as individual springs would experience similar impacts as those described for Mulberry Canyon (ID No. 43).

Any intermittent stream segments in Box Canyon not accounted for as individual springs would experience similar impacts as those described for Box Canyon Spring-Stock Drinker Nos. 1 and 2 (ID Nos. 9 and 10), Unnamed Spring in Box Canyon (ID No. 74), and Basin Spring (ID No. 2).

Analysis of impacts to BLM Federal reserved water rights associated with Helvetia, Zackendorf, and Chavez Springs is included in the “Indirect Impacts to Offsite Water Rights” part of the “Surface Water Quantity” resource section of this chapter. Water rights associated with these three springs are likely to be affected by the described impacts. Helvetia is believed to derive water from the regional aquifer and therefore there is a high likelihood of impacting the BLM water right. The source of water for Chavez and Zackendorf Springs is not clear, but if their source of water is also derived from the regional aquifer, impacts to these water rights would also occur.

Phased Tailings Alternative

The estimated impacts to springs and seeps for the Phased Tailings Alternative are identical to those for the proposed action, with the exception that McCleary No. 2 would be directly impacted rather than indirectly impacted. The same riparian areas associated with these springs would or could be impacted. The Phased Tailings Alternative would also directly disturb 649 acres of xeroriparian habitat associated with onsite washes.

Barrel Alternative

The Barrel Alternative would directly impact two fewer springs than the proposed action: McCleary Dam and Unnamed Spring No. 5. Instead of being directly impacted, these springs would be indirectly impacted.

- McCleary Dam would have a high likelihood of indirect impacts because observations indicate consistent water presence and suggest a regional source of water and because it has hydroriparian/mesoriparian habitat associated with it that would be lost or that would experience reduced vitality.
- Unnamed Spring No. 5 would have a possible likelihood of indirect impacts because the water source is uncertain and because it has xeroriparian/mesoriparian habitat associated with it that may be lost or that may experience reduced vitality.

The Barrel Alternative would also directly disturb 588 acres of xeroriparian habitat associated with onsite washes.

Barrel Trail Alternative

The estimated impacts to springs and seeps for the Barrel Trail Alternative are identical to those for the Barrel Alternative. The same riparian areas associated with these springs would or could be impacted. The Barrel Trail Alternative would also directly disturb 633 acres of xeroriparian habitat associated with onsite washes.

Scholefield-McCleary Alternative

The Scholefield-McCleary Alternative would directly impact seven more springs than the proposed action: HQ Water Spring; McCleary No. 2; Scholefield Nos. 1, 2, and 3; Unnamed Spring No. 14; and Water Development Spring.

- McCleary No. 2 was previously considered to be indirectly impacted with a high likelihood.
- Scholefield No. 1 and Scholefield No. 2 were previously considered unlikely to have indirect impacts. Scholefield No. 1 and Scholefield No. 2 have hydroriparian/mesoriparian habitat associated with them that would be lost.
- HQ Water Spring, Unnamed Spring No. 14, Scholefield No. 3, and Water Development Spring were previously considered to have a possible likelihood of indirect impacts. HQ Water Spring and Water Development Spring have hydroriparian/mesoriparian habitat associated with them that would be lost. Unnamed Spring No. 14 has xeroriparian/mesoriparian habitat associated with it that would be lost.

In addition, Mueller Spring would not be directly impacted under the Scholefield-McCleary Alternative. This spring would still be considered to have a possible likelihood of indirect impacts.

The Scholefield-McCleary Alternative would also directly disturb 631 acres of xeroriparian habitat associated with onsite washes.

Monitoring Intended to Assess Potential Impacts to Seeps and Springs

One additional monitoring measure has been incorporated into the mitigation and monitoring plan to address uncertainty associated with impacts to seeps and springs (see appendix B for full details). The additional monitoring includes:

- **Spring, seep, and constructed/enhanced waters monitoring (FS-SSR-02).** A suite of selected seeps and springs has been monitored for baseline conditions since 2007 and would be monitored to identify any impacts that may occur due to dewatering of the regional aquifer in the vicinity of the mine pit. Specific seeps and springs included in this monitoring are listed in appendix B.

Cumulative Effects

The analysis area for cumulative effects on seeps, springs, and riparian areas is the same as that used for the direct and indirect effects on these resources. It includes the immediate Rosemont area, all of Davidson Canyon, and portions of Cienega and Santa Cruz Basins (see figure 66). The analysis area extends east 0.5 mile beyond Cienega Creek; west and south to the approximate modeled 5-foot groundwater drawdown contour; and north to the Pantano Dam. This cumulative effects discussion addresses the cumulative impacts of the action alternatives and any applicable reasonably foreseeable actions as identified on the Coronado ID team's list of reasonably foreseeable future actions, provided in the introduction to chapter 3. The following reasonably foreseeable actions from that list were determined to contribute to a cumulative impact to seeps, springs, and riparian areas:

- The BLM and AGFD are proposing reintroduction of beaver into Cienega Creek at Las Cienegas National Conservation Area. The timing of this potential action has not yet been determined.
- The Forest Service is proposing to reauthorize the grazing permit for the Gardner allotment, located 5 miles north of Sonoita.
- The BLM proposes to approve an MPO to expand the Andrada Mine limestone quarry in the Davidson Canyon drainage system north and northeast of the Santa Rita Mountains. The Andrada Mine is located approximately 4 miles from the Tucson, Arizona, city limits and 1 mile from the Vail, Arizona, city limits.
- The Forest Service proposes to add, decommission, close, or change designation of roads in the NFSR database and prohibit off-road motorized travel for dispersed camping in certain areas on the Nogales Ranger District.
- The Nogales Ranger District proposes to remove hazardous fuels on 2,500 acres in Hog and Gardner Canyons on the Nogales Ranger District.
- Development of the Farmers Investment Company property within the Town of Sahuarita's jurisdiction over the next 40 to 50+ years for residential and commercial mixed use is proposed, along with the enhancement of more than 12 miles of the Santa Cruz River in both the town of Sahuarita and Pima County.
- In May 2010, a lease was granted to Charles Seel for mining purposes for 240 acres of ASLD State Trust land (from State land commissioner) in Section 29, Township 17 South, Range 17 East, adjacent to CalPortland leases in Davidson Canyon. There are no known plans to explore for or develop mineral resources on this lease in the foreseeable future.

As part of changes to the Nogales District Motorized Travel System, the Coronado proposes to add, decommission, close, and/or change road designations, which could include prohibiting off-road motorized travel for dispersed camping in certain areas. These activities could change the characteristics of the watershed. Closing roads or prohibiting off-road motorized travel to dispersed camping areas could have the potential to reduce stormwater runoff from an area. Changes in stormwater runoff could affect the availability of water for seeps, springs, and riparian areas.

The Gardner allotment is located 5 miles northwest of Sonoita, and the Coronado is proposing to reauthorize the grazing permit on 10,271 acres. This reauthorization is for issuance of a new 10-year term grazing permit that would allow for an increase in animal unit months (AUMs) and would change the Gardner allotment from seasonal use to year-long use. An adaptive management approach is being proposed for the allotment, and several range improvements are being considered to help better distribute livestock. Continued grazing and increases in AUMs would likely result in increased livestock use of surface water. Changes in grazing management practices could change existing characteristics of the watershed and stormwater runoff, thus affecting the availability of water for seeps, springs, and riparian areas.

Hazardous fuels in Hog and Gardner Canyons are proposed to be removed from more than 2,500 acres of Coronado National Forest land. These activities would be expected to disturb vegetation and change the characteristics of the watershed involved. The use of best management practices would minimize the potential these activities have to impact seeps, springs, and riparian areas.

Expansion or construction of limestone quarries within the Davidson Canyon drainage has the potential to both directly impact riparian resources as well as to change the hydrologic flow regime. In conjunction with the changes in flow described above for the Rosemont Copper Project, there could be a greater combined effect on xeroriparian vegetation along Davidson Canyon from additional surface water loss.

Enhancement of the Santa Cruz River near Sahuarita would have a beneficial impact on riparian resources. However, these changes are geographically separate from any impacts to riparian resources that would or potentially could occur due to the Rosemont Copper Project. These enhancements are envisioned as part of master-planned communities and would be undertaken by whatever entity is constructing these communities after appropriate permitting.

Reintroduction of beaver along Cienega Creek would be expected to have a beneficial impact to riparian resources by slowing and ponding runoff and increasing water availability, and it would have a detrimental impact from use and falling of larger vegetation and trees. Overall, the intention of beaver reintroduction is to have a beneficial impact on Cienega Creek. Cumulatively, this would potentially offset any impact that could occur due to dewatering of the regional aquifer; however, cooperating agencies have commented that the benefits of this action have not been determined and are in dispute.

Climate Change

As discussed earlier in this chapter, climate change in the desert Southwest is predicted to bring about higher mean annual temperatures over the next 100 years, along with less winter precipitation, an increase in extreme rainstorms and flooding, and longer periods of drought. The extent to which these predictions will occur is uncertain, and the overall difference in the amount of annual precipitation is impossible to accurately quantify. However, predicted changes in weather patterns could have an effect on the quantity of stormwater and groundwater available for use by riparian vegetation. Increased temperatures and reduced precipitation will increase the vulnerability of springs and riparian systems relying on the groundwater system, whether regional or local.

The cumulative impact to these riparian systems from prolonged droughts can presently be observed from the decade-long drought that is currently ongoing. The Pima Association of Governments reports on conditions within the Pima County Natural Preserve, which encompasses a large portion of Lower Cienega Creek both above and below the confluence with Davidson Canyon (Cienega Creek Reaches 4 and 5). Stream flow monitoring (wet/dry mapping) has occurred since 1984 (Pima Association of Governments 2012a; Powell 2013). The percentage of Cienega Creek flowing in this area is cyclical but has steadily decreased since monitoring began in 1984. Since 1999, drought monitoring has been conducted, and measurements in June 2011 indicate that this portion of Cienega Creek has the least percentage flowing yet observed. Only 13 percent of the stream exhibits flowing or standing water, compared with the wettest year (2001), in which 49 percent of the stream exhibited flowing or standing water, and more normal years, in which roughly 30 percent of the stream exhibited flowing or standing water. Between 1990 and 2011, surface water discharge in Cienega Creek declined by 83 percent, while stream flow extent declined by 88 percent (Powell 2013). The exact causes of this multidecade decline are not entirely clear, as several possible stresses may be acting in concert, but the current drought cycle is considered one of the primary reasons.

The patterns seen in southern Arizona in the past few decades, and particularly on Cienega Creek, provide a template for what long-term climate change could look like. Prolonged droughts brought on by climate change could result in similar shifts from perennial to intermittent flow along upper Cienega Creek and Empire Gulch. This would increase the sensitivity of these areas to any drawdown in groundwater due to the mine pit, increasing the overall impact to stream flow, wetland complexes, and hydroriparian habitat.

Mitigation Effectiveness

Measures that would mitigate impacts to seeps, springs, and riparian areas include design features, and mitigation measures proposed that would be required either in the biological opinion or the CWA Section 404 permit. See appendix B for the full "Mitigation and Monitoring Plan."

Mitigation and Monitoring – Forest Service

- **Growth media salvage and application (FS-SR-01).** In order to support reclamation activities, soil and other growth media would be salvaged, stored, and applied to the surface of the perimeter waste rock buttress and waste rock and tailings facilities in order to facilitate revegetation. This allows as much stormwater as possible to move downstream to support riparian vegetation.
- **Revegetation of disturbed areas with native species (FS-SR-02).** Reclamation efforts would include revegetation of native grasses, forbs, shrubs, and trees on areas disturbed by mining and mine related activities. Revegetation would include detection and treatment of invasive weed species. This allows as much stormwater as possible to move downstream to support riparian vegetation.
- **Concurrent placement of perimeter buttress (FS-SR-03).** Placement of the perimeter buttress would allow reclamation activities to take place earlier, concurrent with mine operations. This allows as much stormwater as possible to move downstream to support riparian vegetation.

- **Location, design, and operation of facilities and structures intended to route stormwater around the mine and into downstream drainages (FS-SW-01).** Various stormwater diversion channels and location of facilities have been designed and located in order to maintain flow downstream as much as possible and avoid contact of stormwater with processing facilities and ore stockpiles. This allows as much stormwater as possible to move downstream to support riparian vegetation.
- **Stormwater diversion for Barrel Alternative designed to route more stormwater into downstream drainages postclosure (FS-SW-02).** Following publication of the DEIS, the Coronado undertook an effort to apply the concepts of geomorphic reclamation to the Barrel Alternative. The result is a design that would route more stormwater into downstream drainages postclosure than previous designs.
- **Purchasing of water rights, to be used for mitigating impacts in the Cienega Creek watershed (FS-SSR-01).** This mitigation measure includes a suite of actions that involve purchasing, severing, and transferring existing senior water rights on Lower Cienega Creek. The water rights would be transferred to appropriate entities to become in-stream flow rights on Lower and Upper Cienega Creek. Additional actions could include the discharge of water below Pantano Dam potentially could enhance and support riparian areas, along with retirement of a groundwater pumping well near to Lower Cienega Creek.
- **Spring, seep, and constructed/enhanced waters monitoring (FS-SSR-02).** A suite of selected seeps and springs has been monitored for baseline conditions since 2007 and would be monitored to identify any impacts that may occur due to dewatering of the regional aquifer in the vicinity of the mine pit. Specific seeps and springs included in this monitoring are listed in appendix B.
- **Recordation of a restrictive easement on private land parcels in Davidson Canyon to potentially mitigate for loss of habitat for listed species (FS-BR-21).** Rosemont Copper would record restrictive covenants to preclude real estate development and similar land use activities. Managed grazing, cultural, and some low impact public use (hiking, bird watching, minor forms of hunting) would be allowed in some locations. These lands total 383 acres and include portions of ephemeral wash, riparian habitat in Davidson Canyon, Barrel Canyon, and Mulberry Canyon, upland buffer habitat adjacent to riparian areas and three springs.
- **Plant site location and design adjustments to reduce impacts to biological resources (FS-BR-01).** The entire plant site is sited and designed to reduce its size and overall footprint and to use gravity instead of pumping to move process water where possible. This reduces the amount of xeroriparian vegetation impacted, particularly in McCleary Canyon
- **Construction, management, and maintenance of water features to reduce potential impacts to wildlife and livestock from reduced flow in seeps, springs, surface water, and groundwater (FS-BR-05).** Up to 30 water features, including stock ponds, would be enhanced and managed for sustainability of surface water. These waters would be constructed or managed if needed based on impacts observed in the field. While considered primarily for mitigation for impacts to biological resources, it would also mitigate effects on surface water resources and riparian resources.
- **Recordation of a restrictive easement on the private Sonoita Creek Ranch parcel to mitigate for impacts to species listed as threatened or endangered (FS-BR-08).** Rosemont Copper would record a restrictive covenant on the 1,200-acre Sonoita Creek Ranch parcel and the accompanying 590 acre-feet of certified water rights. The parcel includes open water, forested wetland and riparian habitat, upland habitat adjacent to riparian habitat, seasonal

ponds, semi-desert grassland, and ephemeral drainages. In the event that restoration is required to mitigate impacts to WUS, Rosemont Copper would use the existing infrastructure and the naturally occurring water from Monkey Spring (that currently irrigates the agricultural fields) to create riparian and/or wetland habitat within the 115-acre fields. Otherwise water available after the needs of the existing ponds would be discharged onto the floodplain terrace of Sonoita Creek, which is currently an agricultural field, in order to facilitate the passive restoration of riparian habitat.

- **Establishment of the Cienega Creek Watershed Conservation Fund, to be used for future mitigation to in the Cienega Creek watershed (FS-BR-16).** Rosemont Copper would establish an endowment and provide $2,000,000 of funding. This fund would essentially be established as a resource to help restore the watershed to a functional ecosystem and a mechanism to promote adaptive management and allow flexibility in mitigation to achieve desired outcomes in light of future uncertainties.
- **Monitoring to determine impacts from pit dewatering on downstream sites in Barrel and Davidson Canyons (FS-BR-22).** Monitoring would be conducted of surface water, alluvial groundwater, and deeper groundwater at sites in Barrel and Davidson Canyons. Several locations have already been installed and are being actively monitored, whereas others would require access from landowners.
- **Periodic validation and rerun of groundwater model throughout life of mine (FS-BR-27).** This measure would involve basic data collection of water levels, meteorological data, and water balance components, which would allow for the predictions of groundwater impacts to be revised based on actual hydrologic observations. Specific wells to be monitored are listed in appendix B.

Conclusion of Mitigation Effectiveness

Most of the mitigation measures listed above are associated with design features or permit requirements. Some of the design features would reduce the overall footprint of structures or create large stormwater diversions that would directly route stormwater around operations, which in turn would reduce the impact to downstream riparian resources by allowing for more surface water to flow downstream. Other types of design features such as those associated with revegetation of disturbed areas would also reduce impacts to riparian resources by allowing water to be discharged from reclaimed areas as soon as possible during the active mining phase. Removal of unneeded facilities during closure would allow these areas to be revegetated and allow surface water to flow downstream postclosure. These mitigation measures would be effective at minimizing reductions to surface water quantity within the analysis area to the extent possible. However, these improvements in surface flow have been taken into account in the direct and indirect effects analysis, and impacts to downstream riparian resources are still expected.

The lands proposed for conservation within Davidson Canyon would be effective at avoiding future impacts to xeroriparian resources located along Davidson Canyon by establishing conservation easements limiting certain types of land use. The lands proposed for conservation at Sonoita Creek Ranch would be at least partially effective at mitigating riparian resources by preserving and possibly creating new riparian habitat; however, it should be noted that these lands are not located within the analysis area or within the Davidson Canyon/Cienega Creek watershed. It should also be noted that sufficiency of the mitigation on the Davidson Canyon parcels or Sonoita Creek Ranch to offset impacts to jurisdictional WUS has yet to be determined by the USACE.

The severance and transfer of water rights on Cienega Creek would not necessarily provide any new or "wet" water in either Lower or Upper Cienega Creek; however, by creating a senior instream flow right where none currently exists, this mitigation measure would provide significant legal protection against future water use that might take water from Cienega Creek, and it would remove legal obstacles to conducting restoration or management activities along Cienega Creek. Cooperating agencies have raised concerns that the sever-and-transfer process that must be undertaken through the ADWR is not guaranteed to be successful and allows for challenges to any transfer of surface water rights. If the water right transfer were not approved, this mitigation would not be protective of Cienega Creek. The exact effects of projects conducted under the conservation fund cannot be known at this time, but these projects would be presumed to be beneficial to riparian resources in some manner, as this is the purpose of the conservation funds. It should also be noted that sufficiency of the mitigation activities on Cienega Creek to offset impacts to jurisdictional WUS, either from transfer of water rights or implementation of conservation funds, has yet to be determined by the USACE.

If successful, the new riparian habitat that would be created downstream of Pantano Dam would replace hydroriparian habitat if any is lost, although these lands are located just outside the analysis area. However there is uncertainty associated with the hydrogeologic characteristics of the stream channel downstream of Pantano Dam. While release of water to the stream channel or uplands would certainly help create and maintain riparian habitat, the recharge of water to the aquifer may not cause the water table to rise shallow enough to support hydroriparian habitat. This depends on the depth to bedrock and other subsurface characteristics of the aquifer immediately downstream of Pantano Dam. It should also be noted that sufficiency of the mitigation proposed at Pantano Dam and in the stream channel downstream to offset impacts to jurisdictional WUS has yet to be determined by the USACE.

The creation, enhancement, or replacement of water sources is likely to support additional riparian habitat. The exact location and nature of the habitat that would be supported is not known at this time. These measures generally would not be effective as mitigation but rather would provide a means for monitoring potential changes to surface waters and riparian resources within the analysis area.

Monitoring of groundwater and surface water conditions and periodically rerunning the groundwater model would help inform future decisions. This would include providing input for consideration on implementation of mitigation measures such as under FS-BR-16 and FS-BR-05, developing closure strategies, and providing information to support adaptive management of the mine.

Effects of Amending the Coronado Forest Plan

The effects on seeps, springs, and riparian areas from amending the Coronado forest plan are described under "Direct and Indirect Effects" above. The current forest plan does not contain management area standards and guidelines specifically pertaining to seeps, springs, and riparian vegetation for management areas 1, 4, or 7A.

New management area 16 contains a standard and guideline under "Watershed and Soil Maintenance and Improvement" that would apply to seeps, springs, and riparian areas:

1. To the extent practicable, mining facilities and reclamationshould strive to emulate natural hydrologic functions.

Approval of the forest plan amendment would allow actions that would result in impacts to seeps, springs, and riparian vegetation as described in the "Direct and Indirect Effects" portion of this section, including the direct and indirect loss of some springs and the loss and conversion of riparian areas.

Biological Resources

Introduction

This section discusses the affected environment and environmental consequences of the proposed action and alternatives to biological resources. Biological resources include plant and animal populations, as well as other biological and physical resources that provide habitat within the analysis area. The scope of analysis encompasses potential impacts from the proposed project and action alternatives, taking into consideration both the geographic extent (spatial analysis) and duration of impacts (temporal analysis). This section emphasizes potential effects of the project on "special status species," which includes federally listed threatened, endangered, and sensitive species (Forest Service and BLM), as well as some migratory birds and Forest Service management indicator species. Special status species are emphasized because of presumed rarity, conservation concerns, or legal mandates. Not all species considered by the Forest Service in the NEPA analysis are presented in detail in the FEIS; the analysis for many species can be found in reports in the project record, as discussed in the "Analysis Methodology" part of this section.

Changes from the Draft Environmental Impact Statement

Several changes were made in response to public and agency comments on the DEIS and cooperating agency comments on the Preliminary Administrative Review Draft FEIS and to reflect refinement of the action alternatives and connected actions. Below is a bulleted list highlighting these changes:

- Analysis of connected actions was added, including modification of an electrical transmission line, rerouting of the Arizona National Scenic Trail, and highway maintenance and improvements to SR 83 (addressed throughout the "Affected Environment" and "Environmental Consequences" parts of this resource section where applicable);
- Minor changes were made to the "Issues, Cause and Effect Relationships of Concern" part of this section;
- "Issue 4: Impact on Seeps, Springs, and Riparian Vegetation," associated "Factors for Alternative Comparison," and most of the associated discussions for seeps, springs, and riparian areas were moved to the "Seeps, Springs, and Riparian Areas" resource section of chapter 3;
- The "Analysis Methodology, Assumptions, Uncertain and Unknown Information" part of this resource section was expanded upon and clarified, including:
    - Sources used for analysis when species-specific survey data were not available; and
    - A more thorough description of potential for occurrence of species in the analysis area and hence which species are analyzed.
- Information in the "Sonoran Desert Conservation Plan" and associated "Multi-species Conservation Plan" parts of this section was updated;
- The summary table of special status plant and animal species (table 115) was revised:
    - Species that were retained for analysis of impacts for the proposed project were added to the list to reflect:
        - The addition of connected actions; and